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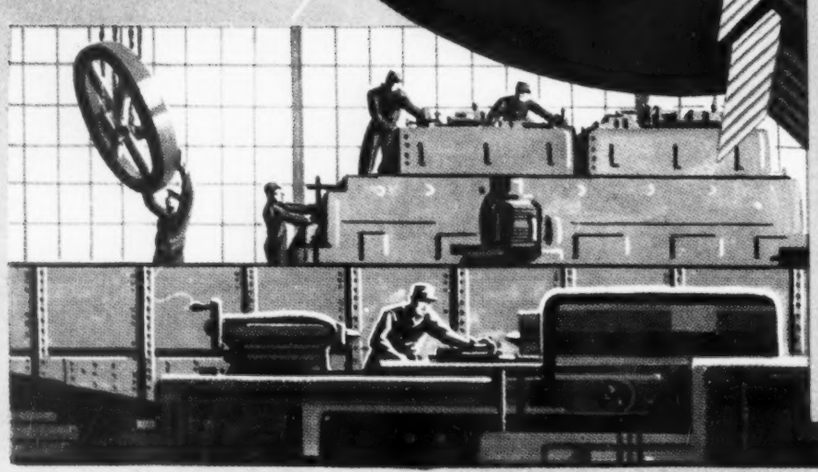
WORLD PETRO

DECEMBER 1942

FROM THE MEN OF CLARK BROS.

to Free Men Throughout the World



A Christmas Message

On this Christmas Day we of Clark Bros. Co. extend greetings to the fighting men of all the United Nations, ashore and at sea, at home and abroad.

We want you to know that our thoughts, our hopes and our prayers are with you today, guiding our actions and spurring us on to meet cheerfully any demands that may be made upon us.

Above all else, we ask you to accept this solemn promise: Never for a moment shall we at home lose sight of the obligation that we owe to those on the firing line. Collectively and individually we pledge ourselves never to let you down by letting up in our production of the materials you need to wage a winning fight.

With you, we look forward to a happier Christmas in the not too distant future. And like you we believe that the more energetically we fight the war, the quicker the return of the kind of holidays we used to know... The Men of Clark Bros. Co., Inc., Olean, N. Y.

WORLD PETROLEUM

Incorporating Petroleum Equipment Exporter

THE MANAGEMENT PUBLICATION OF THE INTERNATIONAL PETROLEUM INDUSTRY

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EDITORIAL

WAR PIPE LINE A SYMBOL OF AMERICA'S WILL TO VICTORY

IN the expressive phrase employed by Secretary Ickes the building of the first section of the War Emergency Pipeline represents "a triumph of team work unsurpassed." Its completion in record time and in the face of unusual difficulties arising from war conditions is a tribute to the skill and enthusiasm of the thousands of workers engaged in the task; to the organizing and managerial ability and drive of those who have directed the operation; to the high technical efficiency of the engineering staff, and to wholehearted cooperation of the various governmental agencies concerned.

In the construction of the first leg of this great cross country conduit the special problems of adapting equipment to the handling of pipe of unusual size and weight, of economizing in the use of critical materials, of battling floods and penetrating swamps and crossing swollen rivers, have been met and solved by the men of long practical experience who contracted for the building of the line. The successful completion of this first section promptly on schedule gives assurance that the construction of the urgently needed extension to the Eastern Seaboard which is now getting under way will be pushed through at top speed and that the whole undertaking will stand as an enduring monument to the resourcefulness of the pipe line fraternity in meeting any emergency with which it may be confronted.

While the building of the "big inch" line carries the element of dramatic interest attaching to any outstanding feat of adventure or industry it is only one, though perhaps the culminating one, of a group of developments that are being combined to provide a system of transportation that will effectively free the eastern seaboard from dependence upon the ocean routes which have served it in the past. At the same time it will perform a service of incalculable value in facilitating the movement of war products to battlefronts in Europe, Africa or wherever else they may be established in that part of the world. The report presented by Major J. R. Parten, Director of Transportation, Office of Petroleum Coordinator, to the American Petroleum Institute, which appears on other pages of this issue, contains an impressive survey of the many changes that are being made in the country's pipe line system as a part of this transformation. Included are connections and extensions which will convert existing local lines into through routes from the Southwest to the East, the looping of certain lines and installation of pumping equipment to enlarge their capacity, the removal of unused or unessential lines to new locations, the reversal of flow in certain lines from west to east or their changeover from crude oil to products or vice versa, and finally the construction of new lines over routes where they are needed to round out a completed system.

As a result of these numerous changes, which require little space for their recounting but involve a tremendous amount of planning and effort for their actual accomplishment, the movement of oil by pipe lines to the East Coast area has been increased from 42,000 barrels to 165,000 barrels daily. When the first section of the War Emergency line goes into operation 120,000 barrels will be added to the volume of pipe line deliveries to the eastern area. With the eastward extension of this line in service the total pipe line movement will be raised to 500,000 barrels or more daily. Taken in conjunction with the vastly stepped up shipments by rail and the lesser but highly important movement over inland waterways the receipts at East Coast points will be restored approximately to the level at which they stood before the withdrawals of tankers began.

In the discussion of the various measures for increasing the overland flow of oil from southwest to northeast so much stress has been laid upon the relief of gasoline and fuel oil shortages along the Atlantic seaboard that consumers generally may have formed the opinion that once they are in full operation the supply of petroleum products in this part of the country will be as abundant and as freely available as in the days before war had approached the Western Hemisphere. This is a consummation to be desired but not one that should be counted upon too confidently. As overseas military operations expand in size and scope and intensity the demand for oil to keep the machines of war in operation will continue to rise and to rise rapidly. The primary purpose behind the provision of new agencies of transport as behind every present endeavor of American industry is to put more speed and power behind the drive toward victory and every other consideration must give way to that. Lifting the overland movement of oil from 50,000 barrels a day to 1,000,000 barrels is the oil industry's answer to the Axis attempt to cripple this essential part of the war effort. There remains still a substantial margin to be covered and if war demands grow to still greater proportions the solution will be as Major Parten points out, more and more pipe lines.

Photo Courtesy the Lincoln Electric Co.

BASIC PROBLEM OF NATION'S OIL SUPPLY REMAINS UNSOLVED

For the past twelve months the energies of the American people have been concentrated upon the single aim of preparation for waging and winning a war that was not of their seeking. The building of a great army, the swift expansion of marine strength, the creation of the world's finest air armada, the provision of weapons and munitions on a scale hitherto undreamed of — all these have provided tasks of stupendous proportions. In the aggregate they presented demands upon men and material such as no other nation ever has been called upon to meet in so short a period of time. The pace of production has become so terrific that materials which we have grown to look upon as exhaustless could not be produced rapidly enough to feed the machinery set up for their conversion into instruments of attack. The performance that has been accomplished is inspiring. Its results are being recorded in the far reaches of the Pacific, in Africa and wherever fronts are set up.

Since this is a war of oil, waged by machines that would be helpless and useless without it, the oil industry necessarily has had to direct its attention and its energies to carrying on its all-essential part in the struggle. It has had to provide in unanticipated quantities the special types of fuel required to give to the United Nations domination of the air, the sea and, ultimately it is to be hoped, the land as well. It has had to assume unexpected tasks such as the reconstruction of its entire transportation system, the replacement of the nation's lost rubber supply and the development of new processes and products for satisfying requirements that never before existed.

These were the immediate and imperative demands which necessarily received first attention. Fortunately the industry possessed the scientific knowledge and technical skill for meeting them. Through cooperation of the agencies of government the means of obtaining materials for plant construction and equipment have been provided and all essential military requirements have been satisfied promptly and satisfactorily. The programs set up are capable of great expansion as war activities increase and war requirements grow.

Realization of the dimensions which these requirements may attain as the world struggle progresses and of the even greater demands that may come with the restoration of peace is causing more and more attention to be directed to a phase of petroleum activity that has been somewhat neglected in the avoidable preoccupation with the necessities of the moment. This is the matter of discovering new sources of supply and extending the development of proven areas so that production may be maintained and if neecssary increased without injury to existing fields and loss in ultimate recovery.

The urgency of this problem is indicated by the fact that we are using up our known reserves of oil even at the present rate of operation more rapidly than we are adding to them. To maintain the present relationship of reserves to yearly withdrawals necessitates the discovery each year of more than one hundred fields of 15,000,000 barrels each which is above the average size of those located in recent years. Should it become necessary to increase the daily production of crude from the present level of 4,000,000 barrels to 5,000,000 barrels it would require the finding annually of 150 fields equal in size to those discovered in the most successful years of recent oil search.

While the fact that discoveries in the past three or four years have shown a disappointing decline in the quantity of reserves uncovered along with a rising cost per barrel of discovery is regarded in some quarters as a discouraging augury majority opinion among experienced geologists is that the United States still contains great undiscovered oil deposits capable of supporting for many years to come a higher rate of consumption than now prevails. Under present fixed prices, however, the rewards of successful discovery are insufficient to offset the unavoidable losses due to the fact that four out of five exploratory drillings result only in dry holes.

Under the free operation of economic laws this situation takes care of itself. When demand for any commodity rises in relation to available supply its market price advances, thereby stimulating further production. This process has worked consistently in the oil industry as evidenced by the large additions to reserves and production in periods such as the 'twenties when relatively high prices have prevailed. This natural and logical method of stimulating the search for oil which would involve no more than a rise of its price to a parity with other essential commodities is prevented by opposition on the part of Federal Price Administrator Henderson to any increase whatever in the price level prevailing at the low point of 1941 which not only fails to afford encouragement to exploration but does not provide a fair return for the operation of many of the nation's existing wells. As a substitute for the demonstrated effectiveness of reasonable price incentive to oil search the Office of Price Administration has offered only such impractical generalizations as a special reward for new production or a subsidy on drilling.

In this matter the time factor is important since experience has shown that new oil fields cannot pass from discovery to full production in less than three years. The danger of neglect to prepare now for future requirements that certainly will not be less than those of today and may become much greater lies in the possible impairment of existing fields and the permanent loss of hundreds of millions of barrels of oil now counted among known reserves as well as a crippling of the country's ability to maintain its position of industrial efficiency and leadership in a world that is becoming more and more dependent upon oil. The problem is entirely different from that of other commodities where production can be quickly expanded whenever conditions call for such expansion. It should be decided by men who understand the practical conditions governing the development of oil production and not by rigid adherence to a theory that has resulted thus far in the creation of artificial shortages in almost every field to which it has been applied. In some of these the damage can be repaired quickly but in oil it offers a threat to the national welfare that must not be disregarded.

"RECORD OF TEAM WORK UNSURPASSED"

By Harold L. Ickes
Petroleum Coordinator for War

ON August 3, 1942, a veteran pipeline welder burned the stringer bead on two joints of 24-inch pipe, somewhere in Arkansas. The War Emergency Pipeline was underway.

Today, four months later, the first 531 mile leg of the "big inch" is almost ready for its baptismal batch of crude, and the line, in the ground and in imminent prospect to the East Coast, stands as the finest symbol of industry-government cooperation yet constructed—a great tribute to the men of petroleum in this most critical juncture in the Nation's history.

As Petroleum Coordinator for War, it was my privilege to initiate the effort that has at last culminated in the construction of the Texas-Illinois leg of the War Emergency Pipeline, and in the allocation of steel that now insures its extension to logical terminals at refineries on the Eastern seaboard. I know, perhaps better than anyone else, therefore, the calibre of the hands and minds that have been doing the actual work. I know the tireless energy and skill that the men of the petroleum industry have brought to the job of making the "big inch" a reality. I know that to them—those who serve in industry and those who serve on the staff of the Petroleum Coordinator—is due in large measure the credit for the strength the big pipeline will bring to the arms of the United Nations.

When, in July, 1940, I first proposed the construction of a non-sinkable pipeline between East Texas oil and East Coast refineries, I was careful to indicate that in normal circumstances, such a pipeline might not be justifiable economically, but that in the event of a disruption of our regular petroleum supply lines, it would be extremely necessary. War still seemed remote. We were not yet ready for "emergency" thinking. The proposal barely made the pages of the petroleum press.

Then the petroleum pinch on the Eastern seaboard set in. There were those who insisted that it arrived with the establishment of the Office of Petroleum Coordinator, and the implication was obvious—Ickes created the shortage. Would that I had had such power. I might have conjured up the steel with which to lay the "big inch" then and there.

The threat of a petroleum shortage on the Eastern seaboard grew out of the necessity for shifting more than fifty American tankers to the British service. Slowly but surely, expanding military and war industry demands on available internal petroleum transportation facilities increased the threat of more serious problems. And the importance of the Texas-East Coast pipeline grew daily as the alleged fearsome figments of the Petroleum Coordinator's alleged brain became emergencies in fact.

Nevertheless, the shortest memory in the petroleum business will remember with what acclaim the first official proposal for the construction of the line was received by press and populace generally. In the vocalizations of the public reaction there was a note that was a cross between a bronx cheer and a belly laugh. The Eastern motorist was still flush with complacent assurance that oceanic insulation from the scenes of actual global conflict would forever protect his petroleum supply. Thoughts of possible fuel oil shortage were as remote as Pearl Harbor, Pearl Harbor as remote as the moon, and equidistant from Tokio.

But the petroleum pinch was matched by war restrictions on all critical materials, and not until six months after Pearl Harbor, when basic military and civilian requirements for oil faced the ultimate prospect of extreme shortages, was it possible to secure consent for the steel necessary to construct the pipeline.

We got the green light on the steel June 11, 1942. Overnight our construction plans, long prepared by the Temporary Joint Pipeline Subcommittee under the leadership of W. Alton Jones, became operating action. The "big inch" began to roll.

Elsewhere in this issue of WORLD PETROLEUM you can read the play by play record of accomplishment from the "kick-off" to the completion of the Texas-Illinois leg of the line. It is a record of teamwork unsurpassed in the whole panorama of industry enlisted for the war job.

But the men responsible for punching the biggest oil pipeline in the world up from Texas to Norris City, Illinois, are not looking back on laurels hard-earned over the difficult terrain of misunderstanding, delay and wartime operating difficulties. Our eyes are on the battlefronts that lie east of Phoenixville, Philadelphia and New York.

Already, the big "tracs", vanguards for the army of welding, cleaning, doping, covering and backfilling gangs, are rolling the "big inch" eastward. By January the advance will be moving fast. By June the greatest petroleum artery in the world should be ready, barring the unforeseen, to carry its alloted quota of 300,000 barrels of oil a day—fuel for the fronts where victory hangs on the ammunition that is petroleum. The "big inch" is more than a pipeline; more than an essential tool for civilian sustenance and military might in the crucial days ahead. It is a magnificent idea, attuned to reality by steel and muscle and ability of free men to work together.

For the "big inch", I salute again, the men of America's oil. In the war, as well as in the peace that it assuredly will help us to win, it will serve as a daily reminder of the job so effectively done by the petroleum industry.

Harold L. Ickes

OIL FOR WAR... Industry-Government Cooperation

Builds 24 inch War Emergency Pipeline

WORLD colossus of petroleum transportation, the first leg of the War Emergency Pipeline, goes to war in January. Scheduled for completion this month, the "big inch" will make initial deliveries of oil at Norris City, Illinois, soon after the first of the year. Full capacity delivery of 300,000 barrels per day awaits later completion of all eleven pump stations.

But even as crude and heating oils flow direct from East Texas fields to Norris City for transshipment by tank car, barge, Great Lakes tanker and existing pipelines to the East, the veteran pipeliners who have punched through completion of the first leg of the line in world-beating time, will be stabbing the 857-mile extension to the East across southern Illinois, Indiana, Ohio, West Virginia, and Pennsylvania.

To the man in the street the "big-inch" means the hope of more fuel for his home fires during the winter of '43-'44. Only time and the fortunes of war can determine whether that hope will materialize.

For the merchant mariner and the men of the fighting Navy, the "big inch" stands for assurance of adequate fuel supplies for the stubby hulls of Atlantic convoys and the ships of their fighting escorts.

For the soldier hitting the Axis lines in Africa —and wherever else he may be carrying the fight by the time this story reaches the reader—for him the "big inch" means renewed assurance that his tank can strike, his gun shoot, his jeep roll and his fighting air umbrella sweep the skies whenever the command comes, "Attack!"

To all, in varying degree, the building of the long-sought, sub-proof, non-sinkable gullet for oil-to-the-East, the Texas - East Coast 24 - inch War Emergency Pipeline, is a symbol of splendid accomplishment achieved through understanding cooperation between the petroleum industry and government.

PLANNED BY FORESIGHTED OIL MEN

Supported By Petroleum Coordinator The "Big Inch" Stands as a Monumental Achievement

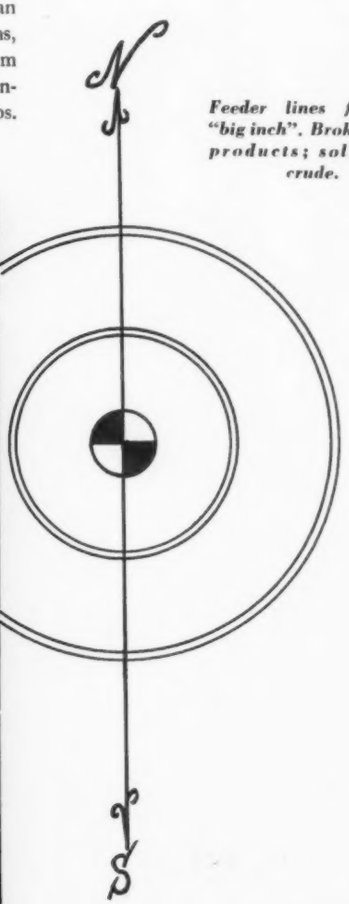
CONSTRUCTION of a large pipe line to extend from Texas to the Atlantic Coast was first proposed by Secretary of the Interior Harold L. Ickes on July 20, 1940. In a report to President Roosevelt on petroleum transportation facilities serving the eastern states he suggested the building of such a line, the construction of additional ocean tankers and a 3,600,000 bbl. increase in the reserve of petroleum products in the East Coast area.

At that time, although it is difficult now to realize the fact, the war seemed far distant to the great majority of Americans and the forecast of possible difficulty in providing ample supplies of oil to all parts of the country was generally regarded as fantastic. A few men within the ranks of the petroleum industry were sufficiently impressed to begin studying the feasibility of the pipe line proposal. Out of these studies later came concrete information of great value when it became more clearly evident that the established transport system might have to be supplemented by other means.

The Japs supplied the evidence, cleancut and explosive, on December 7, 1941. The assault on Pearl Harbor brought the impending petroleum transportation problem sharply into focus. As an active belligerent with war fronts on two oceans, the United States faced the immediate problem of providing the Navy with tremendously increased numbers of transport and supply ships. It became evident that it would be necessary to divert tankers in increasing number to the movement of fuel for the fleets, to various bases established overseas for the armed forces, and to supply, in increasing magniture, the wartime petroleum needs of the United Nations. Moreover, the first offensive launched by the Axis powers against the United States took the form of a powerful submarine drive against ocean tankers in the Atlantic and resulted in heavy losses of ships before protective convoy measures could be put in effect. It became clear that deep water vessels no longer could be used to supply the internal requirements of the country; they were too urgently needed for operations directly connected with the war. The very situation which the proposal for a big Texas-East Coast pipeline had sought to forestall had arisen; the lines themselves were not in existence.

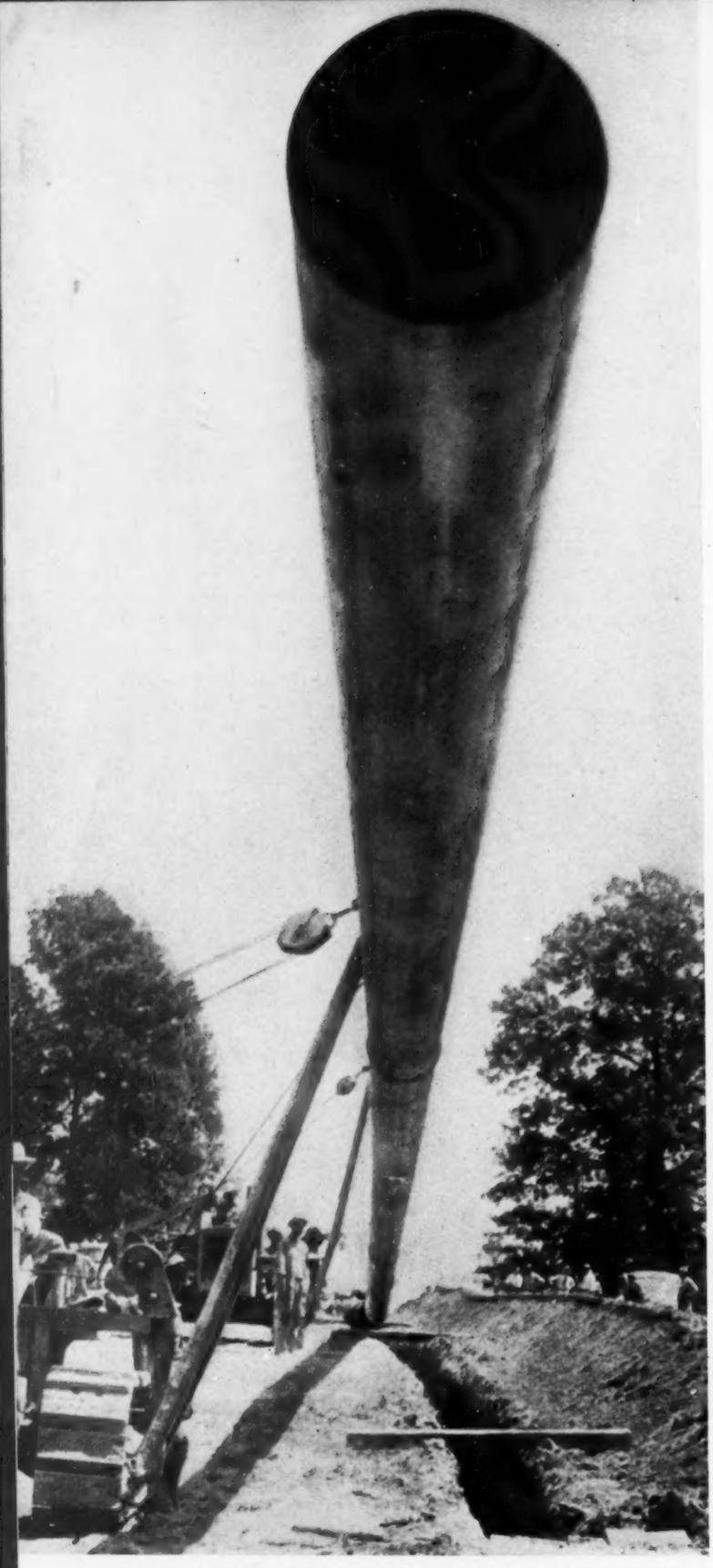
In the thinking of informed minds within the petroleum industry and in government, the construction of a large pipe line for the overland transmission of crude and fuel oils—and the distinctly possible need for building a second great pipe line for the transmission of petroleum products from the Southwest to the critical East—became a "must" for the emerging pattern of petroleum's role in war.

On other pages there is recounted the history and headaches of the effort to get the job under way. It suffices here that hard work and mutual understanding on the part of America's petroleum industry leaders and the Office of Petroleum Coordinator finally accomplished the job. From Texas to southern Illinois the "big inch" is in its trench—shortly to bring essential aid to the fighting arms of the United States and its Allies.



Feeder lines for the "big inch". Broken line, products; solid line, crude.

The "big inch" right of way from Longview, Texas to Norris City, Illinois spans four state lines, nine rivers and a sufficient variety of swamp, rubble, forest and field to try the soul even of the veteran pipeliners who attacked the job in August. Moreover, every 40 foot joint of "big inch" pipe weighs approximately 3784



"Big Bertha" for the oil that is ammunition, the "big inch" points up and eastward above rolling country in Arkansas.

Clearing gangs raze the extra wide right-of-way with axes, saws, dynamite and fire.

pounds—two tons of tough tubing in any cat operator's language.

Those were the principal difficulties which faced the seven contractors who set-in for the task. These basic conditions had to be mastered before the job could roll.

One of the primary problems, therefore, which had to be solved was the assembling of sufficient heavy equipment to handle the 24-inch pipe and its adaptation to the weight and dimensional requirements of the big tube.

Not all adjustments could be made in advance of actual construction and constant refinements in equipment have been characteristic of the progress on the job. From stringing trucks to backfill "cats", construction equipment has been in process of improved adaptation right from the kick-off to the present and construction progress on the eastward extension will undoubtedly benefit materially from the ironing-out and shaking-down of equipment and procedure accomplished during the building of the south-north leg of the line.

For work on the "big inch" the principal stringing contractor redesigned trucks, tractor equipment and winches in order to handle the heavy pipe under a wide variety of right-of-way conditions.

Larger ditching wheels with heavier routers had to be fitted to regular ditching machines with all the attendant problems of power and maintenance.

Out on the line with the welding gangs, new bending shoes, bigger and tougher than any heretofore required for pipeline construction, were built in the field and so rigged that one D7 cat with special winching equipment can make a 5-degree hot bend in less than 10 minutes. Cold bends are made with three D8 cats—two bucking the pipe ends and one drawing the bow—where roll-weld rather than stove-piping operations make this method practicable.

One of the chief equipment difficulties, not yet completely solved, has been the problem of securing sufficient numbers of D8 tractors required universally for safe, efficient handling of the 24-inch pipe.

The tremendous expansion of construction work on military bases, war plants, airports and highways has put a high premium on heavy-duty tractors and tractor equipment with the result that "big inch" contractors have had to make old and lighter "cats" perform work under conditions for which they were not intended, or delay construction on some spreads until heavy tractors could be released elsewhere.

Cleaning and doping machines have had to be rebuilt to conform to the 24-inch size as have many of the hand tools and other items of equipment, including everything from chain rollers and dollies to line-up clamps and "stool pigeons."

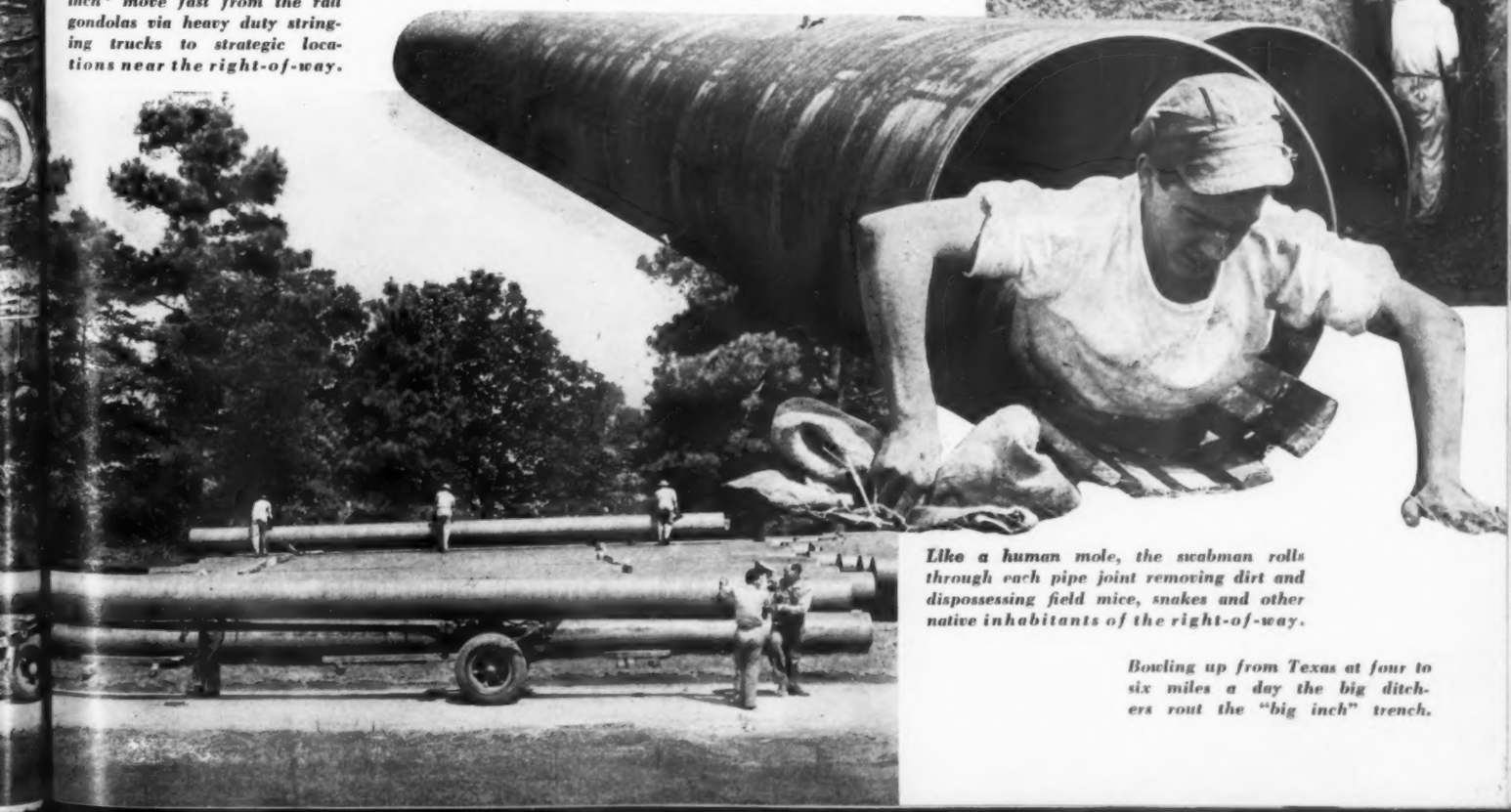
No less important than the redesign and reconstruction of equipment has been the re-adjustment of the pipeliners themselves to the working necessities of the 24-inch job. While many of them, of course, had previously worked on big diameter pipe for gas lines, few had actually been up against such rigid working requirements as have been necessary on the 24-inch oil carrier.

Experienced observers pay tribute to the adaptability of the men as well as to the practical engineering genius of the contractors in adjusting regular equipment to the new requirements of "big inch" construction when they assay the splendid job that has been accomplished to date.

While the "big inch" pipeliners have had to surmount numerous new operating difficulties imposed by the character of the 24-inch pipe and the varied hazards and difficulties of the right-of-way, the organization of construction crews and actual building operations have been essentially the same as those required for the laying of smaller pipelines.

From initial ground reconnaissance to backfill operations have been patterned after military

Forty-foot joints for the "big inch" move fast from the rail gondolas via heavy duty stringing trucks to strategic locations near the right-of-way.



Like a human mole, the swabman rolls through each pipe joint removing dirt and dispossessing field mice, snakes and other native inhabitants of the right-of-way.

Bowling up from Texas at four to six miles a day the big ditchers rout the "big inch" trench.

Veteran welder burns the final bead as his helper observes, ready to wield the wire brush.

tactics to gain the fullest possible benefits of streamlined teamwork among the specialized construction gangs. Every operation has been scheduled and carried out to maintain a smooth flow of advance; pipe-stringing geared to the speed of right-of-way clearing, ditching to stringing, welding to ditching and so on down the line through clean, priming, enamelling, coating, lowering and final backfill.

To the uninitiated, the steady, integrated progress of the spreads has been a source of sincere amazement at the accomplishment of such streamlined operations in the field. Old-timers at pipelining maintain a craftsmanlike blaseness along the line and in the office, but relaxed over a beer in jook-joints from Texarkana to Cape Girardeau, they soften up—admit that the job looks mighty sweet even to a practiced eye.

And it does—except on those occasions when rains turn the bottomlands into a morass soft enough to stall everything on the line except the big D-8 tractors, halt excavation or "pulling" on the river crossings, and generally slow down action from the lumbering ditcher back to the "snitcher" and grey the hair of everyone concerned from the spread foreman to OPC headquarters.

"General" weather still holds command over all pipeliners, but in wartime his ally, and one of the principal enemies of speedy construction, is "Major" manpower.

Prime plague of current war construction, manpower difficulties have beset the "big inch" con-

Rolling north, the big "cats" walk a 3-joint over-bend section into position.

tractors from the start. Spread foremen especially have succumbed to the cash blandishments of contractors on other pipeline projects. As Bill Kinsolving, Assistant Director of OPC's Transportation Division puts it, "It got to be something of a merry-go-round. The modern pipeliner's version of the old 'Tinkers to Evers to Chance play' was 'big inch to Plantation to El Dorado or somewhere else' as contractors bid for the services of spread foremen who they knew could get real distance out of a working spread."

It need hardly be added that the round-robin has been straightened out with straight talk about robbing Peter to pay Paul; while the "big inch" is the most spectacular of the undertakings in the overall pattern of the War Pipeline program, every link in the system of new, re-located, converted or reversed pipe lines is, in terms of the total petroleum transportation problem, equally essential. Nevertheless, the problem did exist for a time and undoubtedly was responsible for some delay.

More important, however, is the fact that draft authorities have not yet given clear-cut assurance regarding deferment for essential war construction duty to draft-eligible pipeliners. The result has been that many men have either been taken from the spreads and into the army or have been required to make extended trips home for appearance before their draft boards. No one has computed the loss of men and time for which these unfortunate situations can be blamed.

On the credit side of the manpower situation, however, it must be noted that several factors

The cleaning and priming crew pause to tune up the machine.

The coating and wrapping machine puts the finishing touches on the 24-inch tube — a heavy coating of dope and a spiral blanket of asbestos felting.

"Snitcher", "holiday detector" or "stool pigeon" — this sensitive instrument checks perfection of "big inch" protective blanket.

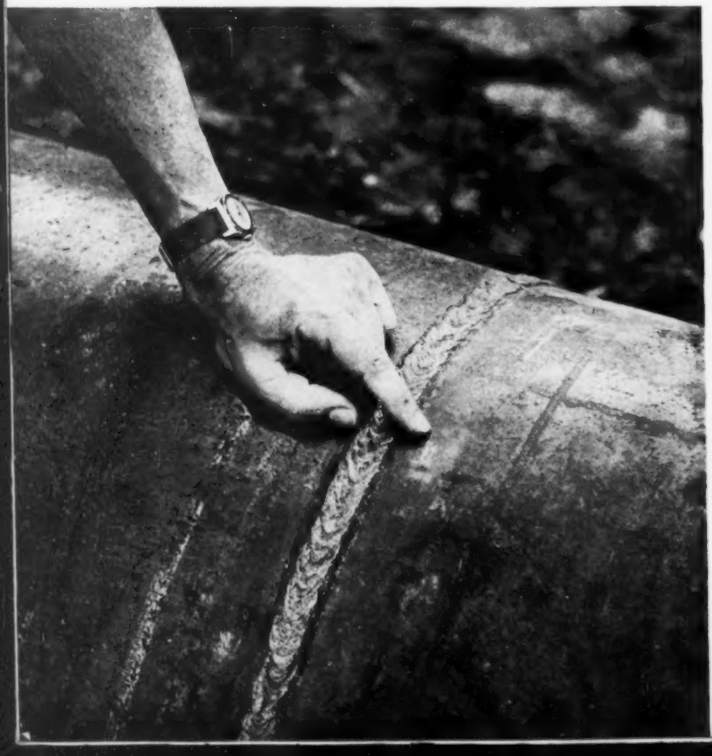
"Commandos of Industry" — men of many lands and races — white, Negro, and American Indian are taking part in the work of construction.

have helped keep down the difficulties that might further have hampered the progress of construction. With traditional individuality and loyalty, the pipeliners have themselves resisted sporadic attempts at union regimentation.

Wages have been "right."

Finally, the "big inch" has, from the start, had an appeal for men of the pipeline game that has brought and held them to the job. Promptly after announcement that the line would roll from Texas to Illinois, the contractors were besieged by able and experienced men of all the pipeline crafts for a chance to "set in" on the biggest pipeline job yet undertaken in this country.

By the time sufficient pipe had been strung to support initial welding and laying operations an army of about 3800 experienced pipeliners had been recruited and were concentrating at kickoff points along the eight spreads into which initial



Every weld is autographed. "Big inch" veteran welder points with pride at one of the more than 46,000 machine welds.

Welding sleeve over a regular pipe weld that will serve beneath an Arkansas River. Note the 4800 pound river clamp and the wooden slats which protect the extra heavy river wrapper when the pipe is pulled into its river trench.

construction operations were divided.

Veteran pipeliners, long-attached to the individual contractors' organizations formed the nucleus of each gang, and experienced reinforcements were soon knit into the streamlined operation.

Only occasional "incidents" have marred the management-labor cooperative spirit and action that has characterized the over-all labor factor on the War Emergency Pipeline. More humor than headache attaches to recollections of these incidents. The fact that the pipeliners were not fully unionized caused a sympathetic strike of bakery truck drivers in one small town in Illinois . . . no one knows quite why. On another occasion dope carriers on one spread decided they were entitled to the dignity of title and the remuneration of "hoisting engineers." After all, they said, "Hoisting is hoisting—hay, dope, or what-have-you." The strike was abortive. Burt Hull offered personally to pay back-wage differentials to the whole group if they would go before the War Labor Board for a ruling. They didn't.

The pipeliners, from Longview to Norris City, have been loyal to the "big inch" as an important, essential tool for war. You sense that spirit immediately when you talk with the men and their superintendents in the field. That is the spirit that has kept the "big inch" rolling.

Arguments for and against the investment required to coat and wrap the first section of the "big inch" were carefully weighed at the outset and a decision reached to apply protective covering throughout. Full covering is considered a substantial safeguard to the capital investment in the pipeline's underground structure.

A cover of coal-tar materials and a blanket of felt will protect the pipeline throughout the 531-mile Texas-Illinois section. (Final decision on coating and wrapping of the eastward extension had not been reached when WORLD PETROLEUM went to press).

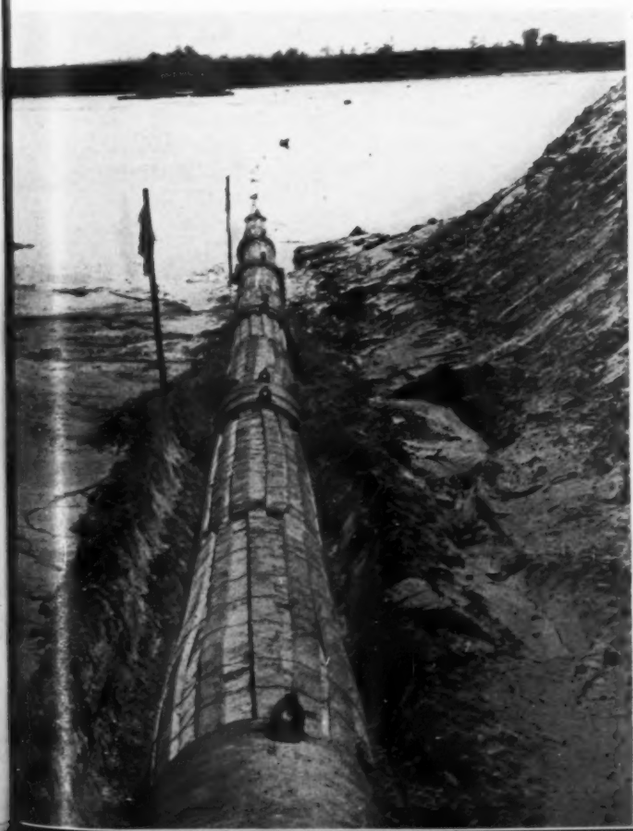
The materials and methods of protection generally follow the procedures established by the oil industry, together with experience from the American Water Works Association, the Natural Gas Industry, and the protective applications specified by several Governmental divisions.

Standard coal tar materials are being used. The first operation is to remove oil, grease, dirt and mill scale from the pipe after welding, and to apply the priming coat. Cleaning and priming is done by elevating the welded pipe with tractors equipped with side booms and cradles to provide clearance for the cleaning and priming machines. The pipe is cleaned by cutters and wire brushes fixed to a rotating head, and at the same time, primed by means of rugs attached to a revolving head at the rear of these machines.

Right: Bull plug protecting end of first joint of the pipe laid in Arkansas.

Below, left: Partially completed river crossing. Note arc of floating buoys showing upstream bend.

Below, right: Finesse on the backfill. A "cat" team putting the "big inch" to bed.



This primer is composed of coal tar pitch combined with solvents, and is applied at atmospheric temperature. The primer deposit forms the bonding agency between the steel and the enamel coating which is applied after the primer is dry.

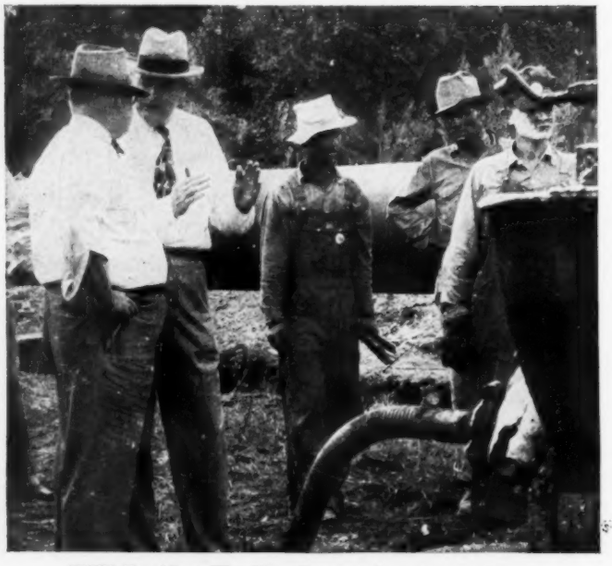
After cleaning and priming, the coal tar enamel is applied to a thickness of 3/32 inch by coating and wrapping machines which apply the enamel to the pipe, and at the same time wrap the felt which serves to shield the enamel from soil stress and mechanical distortion. Coated pipe is handled with wide slings and lowered to padded skids. All areas bearing on skids receive an additional coating of enamel and felt before the pipe is lowered. Paved roads and railroad crossings are pipe-sucased with pipe similarly protected.

River crossing protection at the eight principal streams consists of cleaning and priming, then manual application of three coats of enamel and two plies of felt applied while the individual pipe sections are revolved on rolling jigs. The completed coating is approximately ½ inch thick and permits push-pulling of the pipe across the rivers without injury to the protection.

Application of the coating materials on each of the eight mainline spreads is under the direction of a service man employed by the "dope" supplier, and a WEP inspector double checks all pipe for abrasions suffered in handling.

The electrical "holiday detector" or "snitcher" spots invisible punctures in the coating, and these along with any abrasions are hand coated before pipe is lowered. Experienced observers are of the opinion that the line is receiving very effective protection from the probable action of soil acids and alkalis, which, in combination with electrolysis, might result in corrosion requiring costly repairs and reduction of capacity deliveries of oil to the East.

Vigorous, sincere, able, W. Alton Jones, President of WEP Inc. personifies the spirit of industry-government cooperation which has fostered the "big inch". His drive and understanding are reflected in the world-beating construction record established on the Texas-Illinois leg of the War Emergency Pipeline.



WEP President W. Alton Jones animates a construction detail for an interested colleague on field inspection trip during early stages of construction.

Behind the men who plan and manage the "big inch" building jobs are 4800 pipeliners—an army destined to be more than doubled when work gets fully underway on the extension to New York and Philadelphia. Four hundred and fifty men to a spread, these too are the men behind the men behind the guns.

Laborers
Muckers
Graders
Night Watchmen
Fencemen
Sawfilers
Skid Men
Rag Men
Swab Men
Blacksmith
Measuring Men
Right-of-Way Foremen
Right-of-Way Strawmen

(Continued on page 48)

WAR MADE THE BIG INCH NECESSARY THESE MEN MADE IT FAST

THE great Pacific sneak at Pearl Harbor sealed the "feasibility" of the Texas East pipeline, and justified, in one fatal, historic moment, all the thinking, planning and pre-approval labor that had been expended in preparation for the day WPB could give the green light on steel.

The go-ahead came on June 10, 1942—all the preliminary work of planning, survey, and other preparation that had been carried out during 1941 proved of immense value in saving time and getting the project off to a flying start. The Reconstruction Finance Corporation, through its subsidiary Defense Plant Corporation, agreed to provide funds for the building of the first section of the line from Longview, Texas, to Southern Illinois at an estimated cost of $35,000,000. On June 12 the order for approximately 550 miles of 24-inch seamless steel pipe was placed with National Tube Company. On June 26 a contract covering construction of the line was concluded between Defense Plant Corporation and War Emergency Pipelines, Inc. On July 15 contracts for laying the pipe were signed with construction companies and on August 3 the first welds were made.

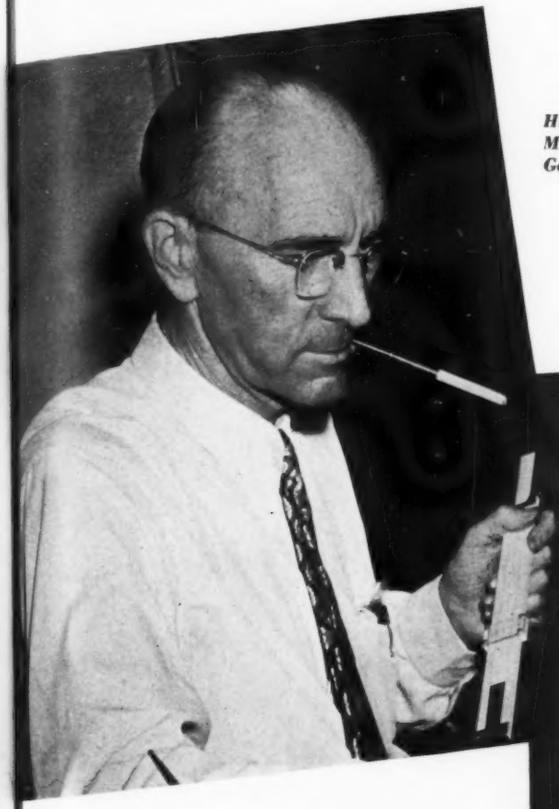
Thus, just 54 days from the date of authorization, the project started to roll—the "big inch" was going into the ground to become a new highway for an endless flow of oil to the critical shortage area in the East. In gestation for two years lacking only forty days (July 20, 1940-June 10, 1942) the "big inch" came to life in less than two months.

From July 20, 1940 when Secretary Ickes first warned of the possible need for a Texas-East Coast pipeline to May 1941 when more than fifty tank ships engaged in petroleum transport from Gulf Coast to Atlantic ports were transferred to service under the British flag for handling petroleum supplies desperately needed by Great Britain, war had mushroomed on every continent except North and South America. The American citizen still blithely assumed that Mars had no designs on us.

The petroleum pinch in the East, coincident with the shift of tankers to British service, nudged our complacency slightly; in the councils of the petroleum industry men went to work studying the impact and the emergency possibilities of war-continued restrictions on petroleum supplies in the areas of potential critical shortage.

A fact-finding committee of the American Petroleum Institute began a study of the situation and its report, completed at the end of that month forecast a probable average deficit for the period from July 1, 1941 to March 31, 1942 of 494,000 dead weight tons, or the equivalent of 49 tankers of average size in the facilities needed to supply the requirements of the eastern states.

Meanwhile, just about the time when this report was ready for submission, the President on May 27 declared the existence of a state of national emergency and on the following day designated Secretary of Interior Ickes as Petroleum Coordinator for National Defense. The report of the American Petroleum Institute Committee, which had been intended to serve for the information of the Office of Production Management was submitted also to the Petroleum Coordinator and was one of the first documents to be put before him in his new capacity.



Hard-hitting field officer on the "big inch," Major A. N. Horne, Vice President and General Superintendent of WEP Inc.

Indefatigable veteran of pipe line construction and operation, Burt Hull, Vice President and General Manager of WEP Inc., is beloved, respected, "big stroke" on the "big inch."

He chairmanned the engineering of the "big inch"—Captain W. R. Finney, recognized authority on pipe line engineering.

Major J. R. Parten, Director of Transportation Division of Office of Petroleum Coordinator for War.

From that time forward the questions of providing alternative means of transportation to replace possible further inroads on the tanker service has been almost constantly to the fore and no man has been more insistent than Petroleum Coordinator Ickes in impressing its importance on Washington officialdom and the public at large. In repeated appearances before Congressional committees and in conferences with other federal agencies he emphasized the necessity of providing for large-scale overland movement of oil from the Southwest to ports and industrial centers of the eastern seaboard. When his proposals were rejected he continued to urge that attention be given to this phase of the situation.

In conferences with various groups of oil men the Petroleum Coordinator and his Deputy, Ralph K. Davies, canvassed the whole transportation situation including the possibilities of increasing shipments by rail and barge and the linking up and rearrangement of existing pipelines but the conclusion reached was that such changes would be inadequate as a substitute for ocean transport.

Secretary Ickes's own views were expressed in the recommendation of a large diameter pipeline to connect the oil fields and refining centers of the southwest with the refining centers and markets of the East Coast. At the suggestion of the Coordinator, an industry committee, made up of executives from eleven companies doing 85 percent of the petroleum business of the East, studied the feasibility of building such a line or lines as he had recommended. The group selected as its chairman, W. Alton Jones, President of Cities Service Company, and appointed an engineering committee under the chairmanship of W. R. Finney to make a complete preliminary study of the economics, design, specifications and aerial survey of the route, of the proposed pipeline to the East Coast. The cost of these studies was underwritten by the oil companies and the work was completed about September 1, 1941. The committee of executives accepted the plan developed by its engineering group. It also decided upon the incorporation of two companies, National Defense Pipelines, Inc. and Emergency Pipelines, Inc., which companies, incorporated in Delaware on September 8, 1941, were privately to finance the building of defense pipelines, the first of which was to be made up of a 20-inch main line from East Texas to Southern Illinois, a connecting 16-in line from Wood River, Illinois, and a 24-inch main line from this junction to the East with branches to the New York and Philadelphia refining centers. These industry plans met with approval of the Coordinator and he immediately advocated the release of the necessary critical materials for the construction of the first big pipeline. Early authorization of the project was anticipated and the industry was ready to start construction work as soon as this authorization could be made.

At this time the Honorable Jesse H. Jones who agreed with the Coordinator as to the imperative necessity for the construction of the big line to the East, as a national defense project, proposed, if necessary, the financing by Reconstruction Finance Corporation of an amount up to 80 percent of the estimated cost of the line.

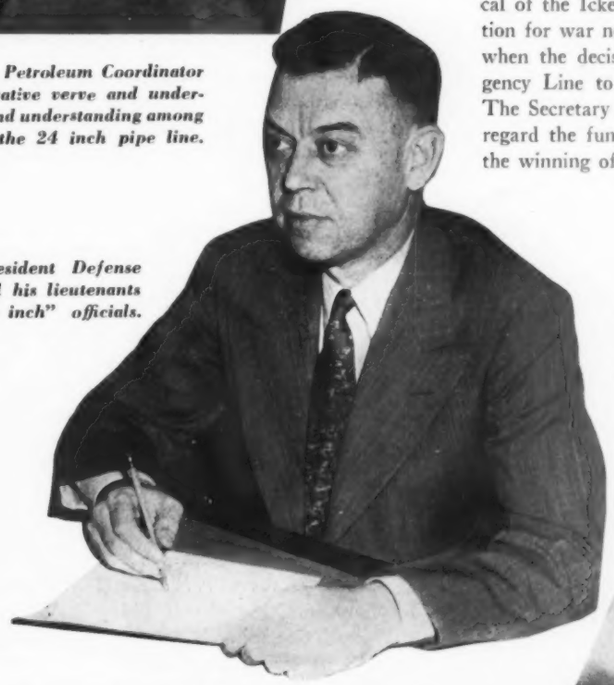
The SPAB studied the Coordinator's proposal but reached the conclusion that the required critical materials could better be employed in other phases of the National Defense program. As a result, the application for the required materials was denied on October 2, 1941. It was about this time that several of the tankers originally assigned to the movement of oil for Britain were returned to American flag service; the East Coast situation appeared to be eased.

Nevertheless representatives of the oil industry, railways, and other transportation agencies organized a tremendous effort to fill the gap in East Coast petroleum supplies caused by the withdrawal of ocean tankers, both actual and impending. Seemingly impossible results were accomplished. Tank car transportation of petroleum products to the East was pushed above 850,000 bbl. daily and at the high point this accomplishment represented a triumph of organization that reflects great credit on all concerned. Petroleum movement by existing pipelines and by barge and on inland waterways was materially increased, but despite all efforts a petroleum transportation deficit persisted and official warning was given that the railways—principal substitute transportation facility—could not maintain the tank car movement at full flood during late fall and winter months.

Under the circumstances the need for greatly expanded pipeline capacity assumed new urgency. In February 1942 Coordinator Ickes again had pressed for consideration of a long distance line and in March he made application to the War

Right: Hon. Jesse Jones, Administrator of Reconstruction Finance Corporation, one who has fully understood the necessity for, and worked to make possible the building of the Texas-East Coast pipe line.

Quiet, forceful Ralph K. Davies, Deputy Petroleum Coordinator for War, whose foresight and administrative verve and understanding have wrought unity of purpose and understanding among the numerous interests responsible for the 24 inch pipe line.



Samuel H. Husbands, President Defense Plant Corporation,—he and his lieutenants worked closely with "big inch" officials.

Below: Judge William P. Cole, Jr., legislator and leading spirit behind recognition of petroleum's tremendous role in war.

Wayne Johnson, Chairman Pipeline Committee, War Production Board economist-engineer whose analytical understanding helped bring the "big inch" to fruition.

Production Board for allotment of 460,000 tons of steel to be used for this purpose. In May he presented a report to the War Production Board which stated that the East faced a very serious oil shortage in 1942, and added that, "In the light of analysis and conclusions presented and in the best opinion and advice of the petroleum industry we recommend . . . the War Production Board reconsidered the application now pending for the necessary materials and equipment for a 24-inch pipeline from East Texas to New York and grant a Project Preference Rating of A-1-A in order that this pipeline can be built without further delay." Faced by mounting demands from every direction which called for steel to be used in planes, in ships, in munitions, tanks and cars, and in the erection of plants for the manufacture of all these necessities, the problem before the War Production Board of deciding which among them was the most imperative was a difficult one. But the developments of the war itself made it increasingly evident that a dependable supply of oil to the Atlantic Seaboard was a primary war requirement, not only to maintain the productive capacity of the eastern states for military supplies but also to save time and ships in the transport of petroleum products to war fronts across the Atlantic. The growing weight of these factors together with studies conducted by the Office of Petroleum Coordinator and members of the oil industry resulted in effecting important savings in equipment and ultimately turned the critical materials scale in favor of the War Emergency Pipeline. On June 10, 1942, the Board approved the projected first section of the 24-inch line from Longview, Texas to Southern Illinois and authorized allocation to it of 137,500 tons of steel.

Thus, after more than a year of discussion, study and survey, the proposal that had been strongly advocated from the beginning of the national emergency by a number of men of foresight in private and public life as essential to the successful conduct of the war finally gained official recognition and approval.

Many men have rendered noteworthy service in bringing this vital national undertaking to fruition. Among them a place of special importance must be assigned to Secretary Ickes. In his capacity of Petroleum Coordinator he early realized the advantages of the line and the invaluable part it might be called upon to play in the nation's defense. Through his advocacy of its construction and his repeated recommendation that the materials required be allocated to it he kept the project before the federal agencies on whom its fate depended until the march of events brought compelling support to his position. Typical of the Ickes attitude toward timely preparation for war needs was his comment at the time when the decision to complete the War Emergency Line to the East Coast was announced. The Secretary said in part: "So important do I regard the function the pipeline can perform in the winning of the war that it is perfectly clear

to me that we must not only complete this line with the utmost dispatch but must immediately consider the advisability of constructing still another paralleling the first."

Throughout the period of planning and preparation the Coordinator's efforts to obtain recognition for the pipeline proposal were actively assisted by Deputy Petroleum Coordinator Ralph K. Davies and by the Division of Transportation of the Coordinator's office under the direction of Major J. R. Parten.

As the funds for the construction of this project are being furnished by Reconstruction Finance Corporation and ownership of the pipeline rests with Defense Plant Corporation, the financial aspects of the undertaking have been in the hands of Samuel H. Husbands, president of liaison representative of the Board in many im-Defense Plant Corporation, who has facilitated the work in every way possible.

The all-important decision of allocating materials for the building of the line rested ultimately with Donald M. Nelson and his associates of the War Production Board. In arriving at this decision an influential factor was Wayne M. Johnson who has acted as a special advisor and portant matters and who made a careful study of the pipeline proposal with particular consideration of the question of how it could be carried out with the least amount of interference with other parts of the war program. Mr. Johnson's work in clearing up difficulties in the path of the project and reconciling conflicting viewpoints is given a high and special rating by those familiar with the course of the matter and it is noteworthy that he served in a similar capacity in connection with the eastward extension of the line which was approved on October 26.

In this connection it should be mentioned that a factor contributing to the rapid progress of the line once its construction was authorized and the needed materials assigned was an act passed by Congress in the summer of 1941. This was the Cole pipeline act which conferred the right of eminent domain on interstate pipelines whenever the President certified that such lines were essential to national defense. Introduced by Representative William P. Cole, Jr., as the last of many constructive proposals dealing with petroleum matters which he sponsored during his service in Congress and strongly urged by the President himself, this act eliminated the possibility of legal delays in providing facilities urgently demanded for the war effort. Though the immediate object of the legislation was to overcome obstacles that were holding up pipe lines then under construction in the southeastern area it of course was equally applicable to the larger undertakings that were to come later and so deserves a place in the picture.

While the various federal agencies concerned with petroleum activities, control of critical materials and financing of enterprises essential to the war have had to determine policy, weigh the importance of the project and pass upon the availability of needed materials the actual work of preparing and carrying out concrete plans for the construction of the line has fallen upon the oil industry. Some of the ablest minds in the petroleum industry have contributed to the job.

When the Petroleum Coordinator set up committees drawn from the industry as part of his country-wide organization, W. Alton Jones was appointed chairman of the Temporary. Joint Pipeline Management Sub-Committee, and when the Petroleum Industry War Council was organized later he was made chairman of the National Transportation Committee and chairman of the Pipeline Managing Committee. At this time petroleum transportation was becoming the principal problem of the oil industry and Mr. Jones, by reason of these positions, has had to deal with the manifold angles of this perplexing subject. His outstanding war work to which he has given unstintingly of his time and energies during the past year and a half in helping to overcome the almost impossible petroleum transportation problems in keeping oil moving eastward, and by his advocacy and working for realization of the big line from the inception of the idea to the present time, led by common agreement and approval to his selection as president of War Emergency Pipelines, Inc. He has played a large part both in paving the way for the world's largest pipeline and in putting through to successful completion in record time the construction of its first section. The qualities of leadership which he had displayed in other branches of the industry have been strikingly shown in the smoothness and efficiency with which the complicated task of laying and equipping a line of unprecedented size has been performed.

The difficult engineering problems inherent in a project of the magnitude of the "big inch" required the best talent that could be enlisted from the ranks of petroleum transportation engineering to do the job. An engineering committee, whose membership represented the principal petroleum suppliers in the East, was formed under the chairmanship of Capt. W. R. Finney of Standard Oil Co. (N.J.), one of the nation's leading experts in pipeline engineering. When the plan for privately-owned lines was dropped because of inability to obtain the necessary steel all these preliminary data were kept available and when the Texas-Illinois line was finally approved they were turned over without charge to the Defense Plant Corporation representing a saving to the government of material sums expended by the oil companies in obtaining them and representing also a saving in time in getting the new project under way which was even more valuable. Naturally enough the company drafted the services of Captain Finney as chairman of its engineering committee.

The field generals in the tremendous job of pushing through the first lap of the "big inch" in record time are Burt E. Hull, vice president and general manager of the company, and his energetic associate, Vice President A. N. Horne. "Burt" Hull, as he is best known to almost every practicing pipe liner in the Southwest, was drafted from the job from his position as president of the Texas Pipe Line Company. As an outstanding authority for many years in the construction and operation of pipeline facilities, "Burt" was eminently qualified for the job. Thoroughly conversant with pipeline problems from ditching to final delivery and an indefatigable worker of proven ability in getting a job done, his selection as field general for the "big inch" operation was an ideal one.

Burt Hull's direct responsibility is the actual construction job; a responsibility that necessitates his being on the job at all hours to supervise the functioning of all the working "spreads." His colleague in shirt sleeves on the seven-day hours-unlimited schedule, Major "Al" Horne, was formerly manager of the Empire Pipeline Company. Today, fresh from a tour of duty with the Army, he is an able "rock 'em and sock 'em lieutenant" with an equal flair for punching the job through fast and thoroughly.

No small share of the credit for the speedy progress of the great undertaking belongs to the skilled workers who constitute the shock troops of the construction crews. They have wrestled pipe and handled welding tools under almost all conceivable conditions. Some of them have helped to lay other history-making lines across the deserts of Mesopotamia and over the mountains and through the swamps of Colombia and Venezuela. They are the commandos of the industrial world whose relish for a job is measured by its toughness and the difficulties it presents. They no less than other members of the operating staff from top to bottom take pride in the "big inch" not as a monument to their own skill and tenacity but because it is a genuine and important contribution toward ultimate victory in the fight for freedom.

Officers and Directors
WAR EMERGENCY PIPELINES, INC.

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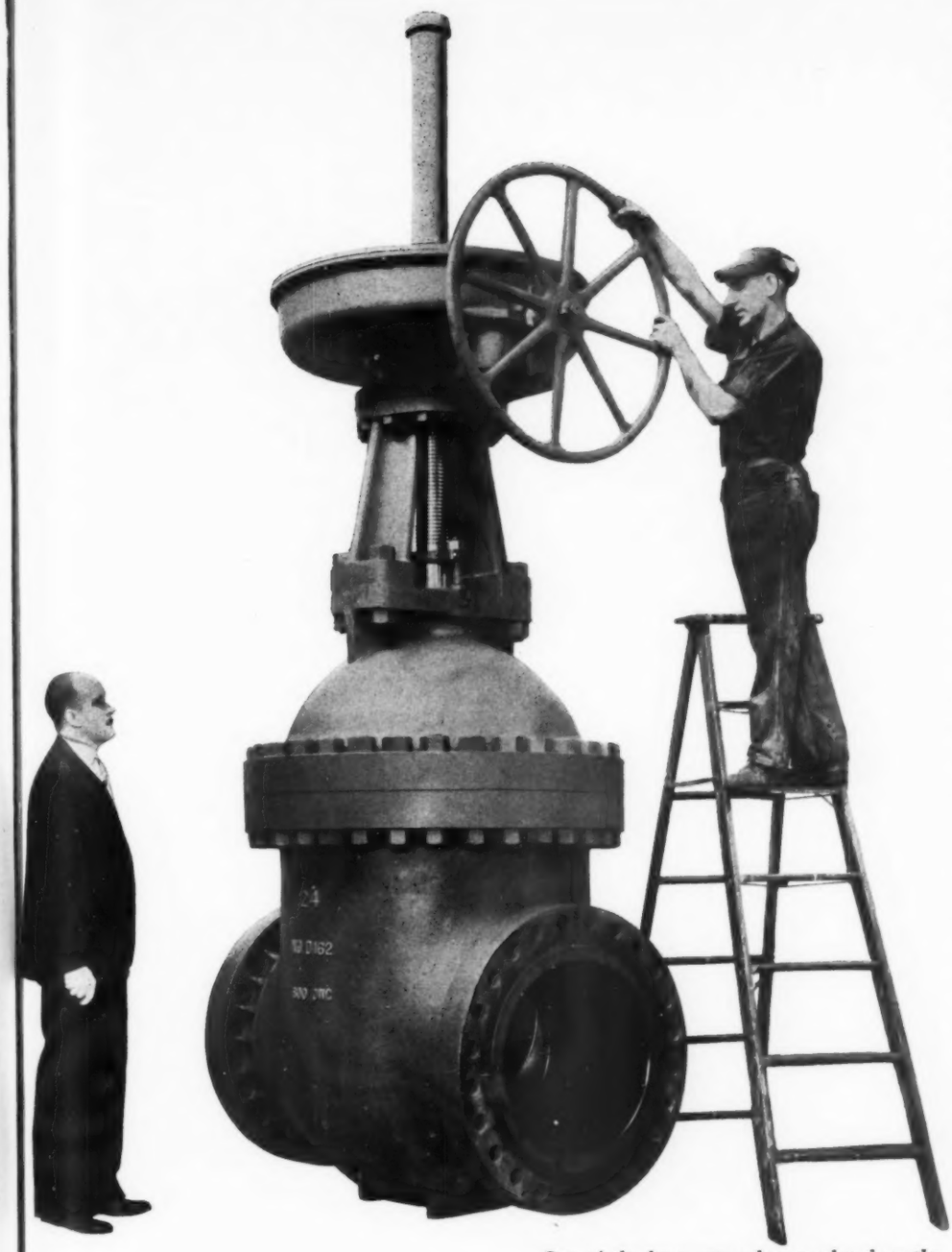
President.....W. Alton Jones
Vice Pres. and Gen. Mgr.....Burt E. Hull
Vice President.....A. N. Horne
Treasurer and Comptroller...Lloyd D. Witter
Sec. General Counsel and
Asst. Treasurer.....Charles I. Thompson
Assistant Secretary.....G. W. Fox
Assistant Secretary.....K. A. Owen
Assistant Secretary.....D. F. Leary

DIRECTORS

John A. Brown — B. I. Graves
Robert H. Colley — W. Alton Jones
J. Frank Drake — Harry T. Klein
Alexander Fraser — J. Howard Pew
Ralph W. Gallagher — Harry F. Sinclair
Robert E. Wilson



One of the huge gate valves employed on the War Emergency Pipeline, weighing 7½ tons; is twelve feet tall, over four feet face to face of end flanges. Photo courtesy Darling Valve & Manufacturing Co.

BIG PIPE LINE ELECTRICALLY OPERATED

Features of Power Supply, Motor Control, Pumping Equipment and Station Arrangement. Same System to be Employed on Eastward Extension

By W. G. Taylor*

* *Industrial Engineering Department General Electric Company.*

WHEN the War Emergency Pipeline project was first given consideration, it was a foregone conclusion that electric motor drive for the pumps was the only practicable method. As compared with other means, electric drive involves the least quantity of scarce critical materials, particularly steel, it lowers the cost of installed equipment, and permits direct connection of efficient high-speed motors and pumps. Furthermore, it also permits the use of smaller station buildings, simplifies operation routine, and assures low maintenance costs, since instruments accurately record electric station operations. Most important of all for the early completion of the pipe line, was the fact that only electric motor drive could be produced under war conditions in the time required to enable the pipe line to be of real benefit this winter in alleviating the oil and gasoline shortage in the eastern states.

On the 531-mile portion of the pipe line now being completed between Longview, Texas, and Norris City, Illinois, the preliminary layout indicated that nine booster pumping stations would be required. From the practical standpoint, however, it was necessary to change some station locations, to avoid a river and a swamp and other inaccessible places. This compromise required the addition of a tenth station. Nine of these stations are each equipped with three single-stage centrifugal pumps, each pump driven by a 1500-hp., 1800-r.p.m., 2300-volt, constant-speed, squirrel-cage induction motor. Because of limited power supply, station No. 9 has been split up into two stations, tentatively called stations 9A and 9B, each supplied by different power companies. Station 9A has one 1500-hp. motor driving a centrifugal pump while 9B has two pumps and motors. All told, then, there are a total of twelve stations, including the present terminus at Norris City.

The first two pumping stations are in Texas, and power is supplied to them at 66,000 volts by the Southwestern Gas and Electric Company. The next four stations are on the lines of the Arkansas Power and Light Corporation, with power supplied at 110,000 volts. Two more stations in Arkansas are supplied with power at 110,000 volts by the Arkansas-Missouri Power Company. The station in Missouri with one motor on the lines of the Missouri Utilities Company receives power at 33,000 volts. All the remaining stations are in Illinois and obtain power at 66,000 volts from the Central Illinois Public Service Company. High-voltage line extensions necessary to reach the pumping stations vary in length from a minimum of one-tenth of a mile to a maximum of 48.1 miles, and amount to a total of nearly 113 miles for all twelve stations. These feeders are all steel-wire circuits, to conserve copper, and each is connected to the power company's transmission line through disconnecting switches of the horn-gap type.

A three-phase power transformer, installed out-of-doors is located at each pumping station to step the voltage down to 2300 or 2400 volts for

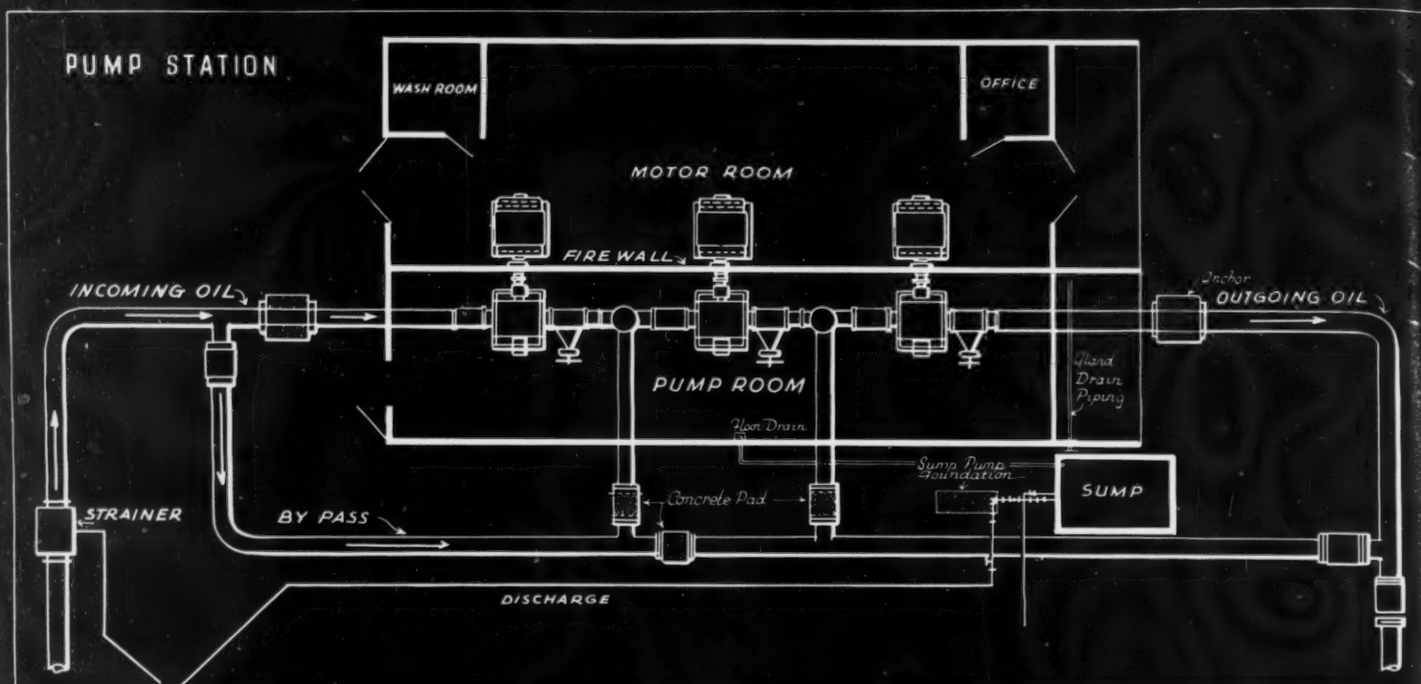


Diagram of typical pump station, showing pump and motor arrangement.

the main motors. Stations with three motors, also the present temporary terminus at Norris City, where three 1500-hp. motors will later be installed, each have a transformer rated 3750 kva. These transformers are designed to accommodate the future addition of fans for forced oil cooling to increase the capacity, and with full-capacity high-voltage taps selected to meet the requirements of the power companies. Station 9A with one motor, and 9B with two motors, are equipped with 1500-kva. and 2500-kva transformers respectively, similar in design to the 3750-kva. units, except that provision for fans was not made on the 1500-kva unit. The outdoor switching arrangements at the various pumping stations differ to some degree in accordance with the requirements of the power companies involved. At nearly all of the stations there are no out-of-door power circuit breakers, but the high-voltage incoming circuit is equipped with fused disconnecting switches. Both high and low-voltage sides of the circuit are protected by outdoor lightning arresters. Power delivered to each station will be measured by outdoor metering equipment. All outdoor equipment is mounted on wooden structures, to conserve steel. At each station, there is an auxiliary transformer bank, located outdoors and consisting of one 25-kva, 2300-115/230-volt and two 15-kva, 2300-230 volt, single-phase transformers. This bank supplies 10-kva, 115 volts, single phase for lighting and for three 1-hp exhaust fans for station ventilation; also 3-phase power for a 20-hp. sump pump motor.

Indoors, each booster station is equipped with metal-clad switchgear consisting of one incoming line unit and a starting unit for each 1500-hp. motor, all built and wired at the factory as a complete assembly ready for operation after incoming lines and motor leads are connected. This type of construction has not only greatly simplified the amount of installation work, but has resulted in a large saving in copper because of the compact design. Electrically operated 2300-volt oil circuit breakers are provided for all power switching, and all main breakers have an interrupting capacity of 100,000 kva. The breakers are suitably interlocked for successive starting of the motors. Of the eleven booster stations, the first seven employ the full-voltage starting method for the main pump motors. At the other stations, these motors are each started, at reduced voltage, from a separate autotransformer.

Although control and switchgear equipment are as vital to the operation of a pipe line pumping station as the motors, to many people the latter are of chief interest because of the direct part they play in moving the oil along to its destination. The 1500-hp. motors on this project are unique, not only in being the largest so far built for this service, but also because of their somewhat special frame design, for discharge of ventilating air from the top of the motor. They are of open, self-ventilated construction, and are located in a motor and control room which is sealed from the pump room by a fire-wall, to exclude any hazardous gases which might be present. The shaft of each motor extends through a sealed opening in the wall and is coupled directly to the pump on the opposite side. The thirty 1500-hp. motors for the portion of the line from Longview to Norris City have been built by two electrical manufacturers to save time, and have been standardized as regards mounting dimensions so that they are interchangeable. Each motor is mounted on similarly standardized sole plates, there being no common base for motor and pump because of the interposition of the fire-wall.

Pressure switches are provided at each station to function on abnormally low or high pressures. When the station inlet pressure drops to 12 lb., pressure switches operate an alarm system. If inlet pressure drops to 5 lbs., the main 1500-hp motors are shut down successively at 2 minute intervals by means of timing relays. If the pressure recovers before all motors stop, this operation is automatically arrested, but motors already shut down must be re-started by the operator. Likewise, switches operating on station discharge pressure shut down all 1500-hp. motors in the station if pressure increases to 900 lbs. and prevent re-starting until the pressure falls to 850 lbs.

With three 1500-hp. motors in a station all operating at full load, approximately 225 horsepower of energy is discharged into the motor room in the form of heat. This necessitates a station ventilating system with exhaust fans, arranged to keep the motor room temperature comfortable at all times and to supply heat to the pump room and, where necessary, to other parts of the station. Normally, motors of this size are designed to discharge air downward at each side, but with three motors side by side this would undoubtedly result in recirculation of warm air through the motors, which might cause their over-heating particularly in the case of the motor in the middle. Furthermore, to pick up air so discharged would require extension of station ventilating air ducts down between the motors where they would interfere with convenience of station operation. These difficulties have been fully avoided by de-

signing the motors to discharge their air from the top, toward the ceiling, where station ducts can readily pick it up without any mechanical connection between the ducts and the motors.

In the Longview station, three 100-hp. motor-driven suction pumps are installed to feed the pipe line. These motors are the totally enclosed, explosion-proof, squirrel-cage induction type, located out-of-doors in the manifold area, operating at 1800 r.p.m., 2300 volts. They are controlled by full-voltage starters of the contactor type mounted in metal-enclosed cubicles on a common sill, and each protected by current-limiting fuses of high interrupting capacity, of the disturbance-free type. These starters were completely assembled and wired at the factory, and installed as a unit. Power is supplied to this control group from the main motor control group by means of extended bus-bars joined in an auxiliary compartment. At Norris City, some oil will be delivered to the Illinois Pipe Line at Centerville Station, Illinois, 16 miles north, through a branch pipe line. Two pumps for this purpose are located in the Norris City Station, each driven by a 350-hp., 3600-r.p.m., 2300-volt, squirrel-cage, open-type induction motor.

All the rest of the oil carried by the 24-inch pipe line will be delivered to tank cars through loading racks at Norris City, this being a temporary arrangement until the remainder of this pipe line east to the Atlantic Coast is completed. Three loading-rack pumps, each driven by a 250-hp., 1800-r.p.m. motor, otherwise like the 350-hp. units, will be installed if the railroad facilities permit. Lacking adequate railroad facilities, two units will be at Norris City and the third at the next pumping station east, Princeton, Indiana. Motors of both ratings are installed with the fire-wall between motor and pump.

The complete control for the 250- and 350-hp. motors is a factory-assembled and wired unit, consisting of a 2300-volt incoming line cubicle with a manually operated oil circuit breaker rated at 100,000-kva interrupting capacity, and four automatic reduced-voltage starters of the contactor type, protected by current-limiting fuses of the same type used for the 100-hp. motors at Longview. All of these cubicles are metal-enclosed and assembled in line, and ready for operation, after connection of incoming line and motor circuits.

At this writing, layout work is progressing on the 857-mile portion of the line finally authorized from Norris City to the Atlantic Coast. At least fifteen more pumping stations will be required. Fourteen of these will each have three 1500-hp. motors installed, and three additional motors will be located in the present terminal station at Norris City. At Norris City, oil will be delivered to sixteen 80,000 barrel tanks holding approximately 4 days' supply. From these tanks, the oil will be pumped into the eastern extension of the line by means of three open-type 100-hp., 1800-r.p.m., 2300-volt, squirrel-cage motors coupled to suction pumps through a fire-wall. These motors will be supplied with full voltage starters of the same type as at Longview. The line will extend across southern Indiana, Ohio, and Pennsylvania to a point near Phoenixville, Pa., where one 20-inch branch will go southeast to the Philadelphia area and the other 20-inch northwest to the vicinity of Bayonne, N. J. There will be 48 more of these motors needed, including three for Norris City, or a total of at least 78 for the complete line from Texas. A preliminary power survey indicates that high-voltage transmission lines are within reasonable distance from each tentative station site, but it is yet to be determined whether there is sufficient available capacity to carry the station load. Of course, the selection of method of motor starting and of interrupting capacity of circuit breakers must await the final results of the power survey. It is very likely, however, that the electrical control equipment in the new stations will largely duplicate that already installed on the portion of the line south of Norris City.

Below: One of the first pumps for the War Emergency Pipeline undergoing test in the laboratory. Photo courtesy Allis-Chalmers Manufacturing Company.

Bottom: Metalclad switch gear used for starting the 1500 hp. main pump motors is shown at the left of this photo. A typical station with three main motors started across the line will have three motor starting units together with an incoming line unit, and an auxiliary unit. Photo courtesy Westinghouse.

Making a hot bend in the field. Ingenuity and speed with accuracy typifies the pipeliner specialists who make the "big inch" roll with the varied terrain.

(Continued from page 40)

Ditch Foremen
Ditch Strawmen
Bending Foremen
Torch Men
Coaler
Bar Men
Stabbers
Clamp Men
Pipe Foremen
Pipe Strawmen
Welders' Helpers
Welders
Jackhammer Men
Powder Monkeys
Dope Foremen
Dope Strawmen
Pot Firemen
Dope Carriers
Dope Pourers
Tractor Swampers

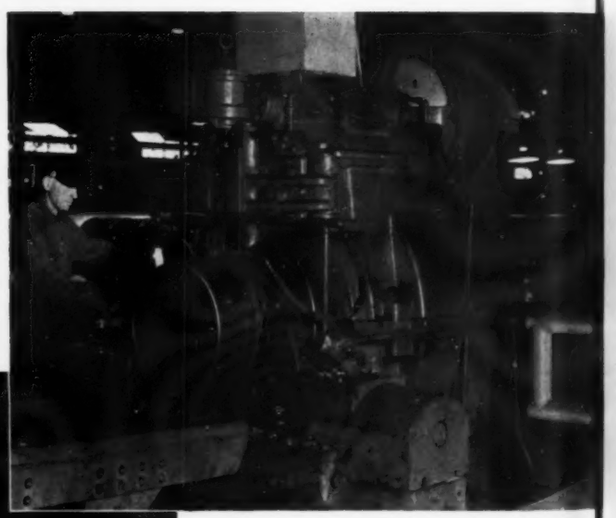
SEAMLESS TUBE FOR THE "BIG INCH"

A solid round bar of steel is heated uniformly to the proper temperature for rolling. The bar is then pushed, on a horizontal trough, into the space between the rolls, the axis of the billet on the inlet side of the mill being coincident with the centerline of the pass. When the rolls have engaged the leading end of the billet the force of the pusher is removed, the obliquity of the roll axes imparting rotation and axial advance.

At the gorge, the leading end of the billet encounters the pointed nose of the piercing mandrel. Actually the piercing mandel is not forced through the billet; rather, the rolls cause the hot metal to flow over and about the mandrel, their grip being sufficient to carry the work piece along against the retarding effect of the piercer. When the rear end of the billet has rolled clear of the piercer point, the mandrel bar is withdrawn and the hollow shell conveyed to a reheating furnace in preparation for additional fabrication into the finished tube. A forty-foot shell for the twenty-four inch pipe can be produced in less than one minute.

The ends of each joint of pipe are bevelled at the mill and are practically ready for the welder's torch when strung on the right of way. Only hand scraping of the bevelled surfaces and an interior swabbing of the joints is required before they can be lined up and the stringer head given.

Veterans of screw-pipe days frown on the current use of the word "stabbing" to describe the line-up of joints for the first weld, but "stab" it is among the "big inch" pipeliners, "stab" and "burn" of an average of 725 points a day!



Heavy machinery bevels the end of each pipe joint at the mill.

First stage in fabricating the 24-inch tube. The hot steel cylinder flows over the piercing mandrel to form the seamless pipe shell.

Winch Truck Drivers
Tow Cat Operators
Flat Bed Truck Drivers
Draw Bar Operators
Oilers
Dope Machine Operators
Cleaning Machine Operators
Bulldozer Operators
Lowering Foremen
Lowering Strawmen
Stool Pidgeon Operators
Daubers
Welding Superintendents
General Superintendents
Ditch Machine Operators
Stringers
Cleanup Foremen

. . . each an essential factor in the job of building the world's greatest pipeline.

Right: Over the hills to the oil-thirsty East. Here the "big inch", ready for war duty, awaits only lowering and backfill. Below: Fabrication completed, hundreds of joints for the "big inch" roll to the loading platform for shipment to strategic points along the right-of-way.

KEEPING THE "BIG INCH" FILLED AND FLOWING

Present plans for maintaining the 300,000-barrel a day through-put of the 24-inch pipeline calls for the reversal of four pipelines into East Texas and the reversal and conversion of one gas line system on the Texas Gulf Coast. In addition, there is likelihood that allowables for fields in East Texas will be increased to insure adequate supplies of crude oil.

The proposed conversion program is being designed around the Magnolia 14-inch gas line from Vanderbilt, and involves the reversal and conversion of a number of small connecting links and the construction with second-hand pipe of 55 miles of additional pipeline. This system will deliver approximately 75,000 B/D of crude and heating oils in the Houston-Beaumont area, for trans-shipment to Longview via the converted lines mentioned below.

The four pipelines due for reversal are:

Sun Stanolind from Beaumont
40,000 B/D heating oil
Shell from Houston . . . 35,000 B/D heating oil
Pan American from Houston
55,000 B/D heating oil
Atlantic from Port Arthur
40,000 B/D crude oil

"WAR" FACTS ON THE EMERGENCY PIPELINE

When completed the "big inch" will deliver sufficient oil on the Eastern Seaboard to permit greatly increased off-shore liftings . . . vital miles nearer and fewer dangerous days to the war fronts of Europe, Africa, Asia.

The "big inch" represents the quickest, safest, most effective method for increasing the capacity of the United Nation's tanker fleet immediately.

When completed to East Coast terminals the 24-inch War Emergency Pipeline will be approximately 1,388 miles in length—the longest, largest oil pipeline in the world. Gathering lines in the Longview area and branch lines on the East Coast substantially increase the total mileage of the "big inch" system.

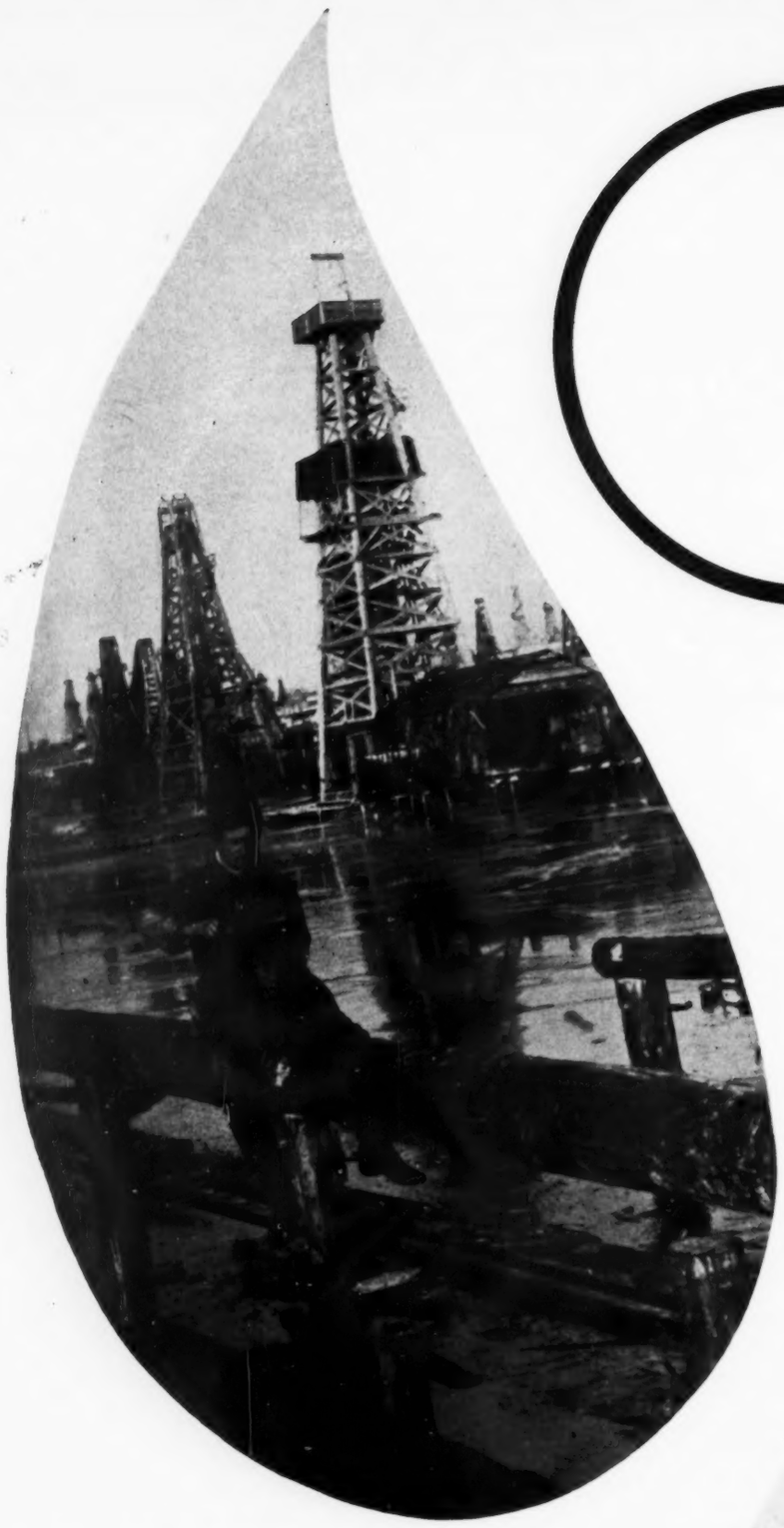
Daily delivery of oil at the New York-Philadelphia refineries will be sufficient, during each five hours of delivery, to float a Victory ship, enough oil to float a Victory cargo fleet of almost five such ships every 24 hours.

Total tonnage of steel required for complete installation of the 24-inch line, including pipe, pumping stations, terminal storage and equipment—367,000 tons.

Total horsepower of pumping equipment, Longview to New York-Philadelphia, 112,500 hp.—60 percent less than power needed for new type ocean tankers capable of equivalent delivery.

Line-fill and working stops for the "big inch" completed to the East Coast, will require 5,000,000 barrels of petroleum.

OIL



Above: When oil was discovered under Lake Ramaninsky, near Baku, the lake was drained and oil wells rapidly sunk in the former lake bottom.

WHEN THE Nazi drive toward the Caucasus was making rapid progress, earlier in the year, reports that seeped out of Germany and appeared in the newspapers of neutral countries stated that a labor corps following in the wake of the army was supplied with drilling machinery, casing and drill pipe and would proceed to put down new wells in Russian oil fields as soon as these fell into the hands of the invaders. The assumption implied in these accounts was that the Russians would destroy all above ground structures in these areas before abandoning them and would blow up or plug the wells themselves so far as possible, but it was pointed out that the Germans were prepared to cope with this situation and could restore production, to a substantial extent at least, within sixty to ninety days after coming into possession of the devastated fields.

At the time when these reports made their appearance the German spearhead was approaching

Right: View of the Kaganovich oil field, in Baku, which was distinguished by its fine arrangement with asphalt roads, and autobus and railway transportation from the workers' residential section to the oil field.

REMAINS ACHILLES HEEL OF NAZI'S MILITARY MIGHT

Evidence Accumulates that Limitations of Aviation Fuel and Lubricants Have Restricted Aerial Operations—Near Eastern Oil Still a Main Hitlerian Objective.

the most westerly of the three principal Caucasian oil fields, that of Kuban-Maikop and it was confidently asserted by Berlin that within the ensuing two months the whole of the rich peninsula between the Black Sea and the Caspian would be under German control. The Nazi plan, according to the statement of one of their own oil technicians who accompanied the army, was to seize possession of the Maikop area by a swift thrust before its defenders could carry out their work of devastation. This program was upset by the final stand of the Russians at the Laba river which permitted the oil workers to carry out carefully rehearsed plans for the removal of all supplies that could be transported and for putting the torch to derricks, tanks, refineries and all surface structures and blowing up the wells themselves. The scorched earth policy was given full play. The conflagration of buildings and oil storage tanks raged in full fury, its heavy smoke obscuring the surrounding area for many days and suspending the advance of the invaders. When the Germans finally got possession they acquired only a mass of smouldering ruins and were compelled to forego their expectation of reinforcing their depleted oil supply. This is the Soviet version of events which is confirmed by independent observers.

Meanwhile one detachment of the German force continued its southeastward drive toward the second objective, the larger oil producing districts of Grozny-Daghestan. This move, however, was halted at the Terek river and in the stubborn fighting in the Mozdok area the Germans have made no progress. The richest part of the Soviet's oil resources, the great Baku district, is still out of reach across a mountain range which presents a formidable barrier. To conquer the narrow mountain passes under winter conditions when they are blocked by snow involves such risks and such certain losses that it is doubtful whether it will be seriously attempted. The lower Caucasus appears to be safe from seizure for the next few months unless the Nazis carry out their oft-repeated threat of a drive through Turkey to reach that region. So far the only part of the Russian oil territory over which the Germans have definite control is the Kuban-Maikop area. Even here their mastery is not undisputed for guerrilla bands are still offering resistance in the region about Novorossisk and Tuapse along the northern shore of the Black Sea which includes Kuban.

Under the disturbed conditions that have existed in this area it seems unlikely that the Germans could have carried on any large scale drilling or have reclaimed any considerable part of the former producing area. It is possible of course that they may succeed in sinking some few wells and developing a small output. The producing horizons vary in depth from 1,500 to 2,500 feet and the structure offers no particular difficulty to penetration either by cable tool or rotary equipment. The former probably is being used if the Germans actually have undertaken to restore production. With the time required for this type of drilling it appears doubtful if enough wells can have been put down to provide any substantial output unless a great number of rigs have been moved in which is improbable.

Whatever the facts may be the Nazi leaders apparently are willing to have the impression spread about that they are in a position to make use of the oil deposits within the section they have overrun. Reports drifting out of the Balkans and finding their way into newspapers in neutral Turkey related that whole train loads of refining machinery are moving eastward through Rumania and Hungary to be set up near the conquered oil fields and would shortly be converting Russian crudes into products for use of Germany's eastern armies. The source of this equipment was said to be refineries in France and Belgium which were being dismantled and transferred to the newly acquired area.

That the Germans are moving refineries from western Europe to new locations very probably is true. Rumors to this effect were in circulation somewhat more than a year ago. At that time, however, the destination set for the equipment was given as eastern Germany, Rumania and possibly Poland. In their original locations, at or near coastal points in France and the Low Countries, the refining plants were of no use to their captors, both because of the inability to supply them with crude and because of their exposure to bombing attacks from across the English Channel. It was believed at that time that much of

Left: View from the sea of the Bay of Ilyich oil field in Baku.

the seized equipment was intended to repair or replace plants within Germany that had been damaged in persistent air raids by British bombers which during the early part of 1941 had German refineries and oil storage plants as one of their chief objectives.

Assuming that the Nazis either have restored a certain amount of oil production in the Maikop district or that they will be able to do so if they retain possession during the oncoming winter the question arises as to the extent to which this new source of supply will relieve Germany's shortage of aviation gasoline, fuel and lubricating oil which seems to have been becoming more of a reality under the heavy demands of the Russian campaign during the past summer.

Production of the Kuban-Maikop fields during 1940 was unofficially estimated at 17,000,000 bbl., or approximately 2,400,000 metric tons. This output was obtained from many hundreds of wells operated by pumping and producing a few barrels per day apiece. If new drilling has been able to bring into production 10 percent of the former number of active wells it would stand as a remarkable achievement by the invaders. Even this relatively small quantity would be extremely useful to the Germans in view of its nearness to the advanced positions of their armies and the saving in transportation as compared to the much longer haul from Rumania or from the Reich itself. It certainly would justify the relocation of a sufficient number of refineries to convert the crude into usable products. Moreover Maikop oil is superior to that of Rumania for the purposes of the Germans since it is a light crude and is accompanied by natural gas rich in propanes and butanes. That a sufficient supply can be developed within a period of several months to satisfy any considerable part of Germany's military needs is difficult to believe.

Rumania remains the chief source of petroleum supply for Germany and Italy so far as the natural product is concerned. Strenuous efforts to stimulate output there appear to have met with only meagre success. Rumanian production has shown a declining trend since 1936 when it amounted to 8,700,000 metric tons. In 1939, the last year for which official figures are available it was 6,250,000 tons. In 1940 it dropped to 5,700,000 tons, and during 1941 according to estimates by those who have had access to reliable information it was a little below 5,500,000. An uncorroborated statement from German sources made the claim that the 1942 output would reach 42,000,000 bbl. or approximately 6,000,000 tons but this is regarded by oil men familiar with conditions as expressing a hope not likely to be realized by actual operations.

Whatever the exact figure of Rumanian production it appears from statements by German officials connected with the administration of oil affairs in Rumania that all but a very small part of it has been used to sustain Axis war activities. The allotment for domestic consumption in Rumania is stated to have been only 200,000 tons plus 10,000 tons for the operation of agricultural machinery and 30,000 tons for other purposes, or a total of less than one-seventh of the normal pre-war consumption.

It is alleged by Nazi authorities that production from the oil fields of the Reich itself has been practically doubled since the commencement of the war. If this claim is soundly based it would mean that Germany's indigenous output was something above 1,000,000 tons. This is regarded as questionable but within the realm of possibility in view of the state of oil development in Germany preceding the war. In addition to these supplies from Germany proper, Rumania and small minor fields under Nazi domination the only other natural reservoir from which oil could be drawn in substantial quantity is Poland. No dependable figures of production from the Polish area have come out since the occupation of the country. It is known however that when the Germans came into control efforts were made to step up the crude output while Nazi officials assigned to the refineries dictated the products to be turned out and the disposition to be made of them. The greater part of these products were shipped to Germany; only an infinitesimal amount being left for local use. Even so the top figure of the quantity of oil obtainable from this quarter can hardly be more than 500,000 tons.

From the start of the war the unknown factor in Germany's oil supply has been the extent of synthetic production. In 1939 this had reached 1,500,000 tons. At that time a number of plants were under construction and it was estimated from the capacity of these plants that the synthetic production would have risen by the beginning of the current year to between 4,000,000 and 5,000,000 tons. It is somewhat surprising therefore to find a German technical writer referring to the annual production of synthetics of about 3,000,000 tons. A possible explanation is that the heavy bombing raids conducted by the British air forces over western Germany where a number of synthetic plants were located may have destroyed or crippled some of them and that the industrial resources of the country have not been equal to the task of replacing these plants at locations in eastern Germany and in Czechoslovakia less exposed to aerial attack.

Survey of the military operations of the past twelve months indicates that something has happened to stay the expansion of German air power and to limit the scope of its activities. While a great number of German planes have participated in the offensive against the Russians and others have had to be assigned to service in Libya and other parts of the Mediterranean area and to the various occupied countries of Europe it has gradually become evident that the German air arm which staged such an overwhelming display of power in the earlier part of the war has ceased to maintain its former position either relatively or actually. For a time it was considered probable that aerial strength was being accumulated for an all-out drive against Britain or toward the Middle East but as the months have passed without the opening of such an attack the opinion has grown that the range of operations of the Nazi

air force has been restricted by lack of equipment or, more probably, by limitations of fuel and lubricants.

If the various evidences previously referred to regarding Germany's current oil situation are correct the quantity of petroleum products available to the Nazi industrial and military machines, including receipts from Rumania and former Poland as well as natural and synthetic production in the Reich, is hardly more than 70,000,000 bbl. or roundly 10,000,000 metric tons. This is far below the amount calculated as necessary by German technical experts in reports prepared before the outbreak of the war and appears wholly inadequate to provide commanding air strength in view of the size of the military campaign that Germany has been carrying on during 1941 and 1942.

In the Polish campaign and in the westward drive through the Low Countries and France in 1940 the Nazis boasted that they captured petroleum stocks much larger than the quantities expended in their own operations but such easy spoils have not been available to them during the past two seasons.

Of possible significance in this connection is a speech delivered some time ago by Propaganda Minister Goebbels in which he told his auditors that "whoever controls wheat, oil, iron and coal and in addition has the strongest army, will win the war." Germany, he asserted, now had immense resources of coal and iron, dominated agricultural areas capable of providing abundant food supplies and very soon would have in its possession the richest oil fields in Europe. That was at a time when the success of the Nazis' eastward drive was represented by Berlin as a certainty within a matter of weeks. The speech was in effect an admission that in the matter of oil Germany still was insufficiently supplied. It provides a key to Hitler's persistence in the long and costly attempt to take Stalingrad. Its overthrow was to open the door to a broad sweep across the Caucasus and perhaps beyond which would put the Nazis in possession of 85 percent of Russia's oil and round out their control of the four essentials of national superiority pictured by Propagandist Goebbels.

Capture of the Grozny oil fields and the far richer prize of Baku was admittedly part of the German military schedule for 1942. The heroic stand of the Russians at Stalingrad and the stubborn resistance of their relatively small forces along the approaches to the southern Caucasus has upset this schedule and has given a respite in which to prepare for further assaults that must be regarded as inevitable. While the German drive has been stayed it has not been rolled back or finally stopped. While the Nazi forces have not been able to accomplish all that they had planned during this year's campaign they have penetrated deeply into Russian territory, have established themselves on the northern shores of the Black Sea and are knocking at the very gates of the greatly coveted oil possessions of the Soviet Union. If the actual advance in the field is suspended for the next few months it is safe to assume that the time will be occupied with preparations for a new and desperate thrust as soon as the men and the materials for such a drive can be assembled. So long as the handicap of insufficient oil remains to prevent the full realization of their potential war strength the Nazi leaders will not balk at any expenditure of blood to overcome it. The critical phase of the struggle to grasp this last important source of power probably lies still ahead but no further distant than the opening of the 1943 campaign.

While Germany's plan to gain control of the oil fields of the Caucasus and the Near East has not yet succeeded, it has not been abandoned. The price already paid in men and materials shows the high value which Hitler places upon this objective and indicates that he will not abandon the attempt to attain it so long as a chance of success remains. At the same time it should convey two instructive suggestions to strategists of the United Nations. The first is the imperative need of preventing the Axis from gaining a position where it can exploit the oil of Baku and from there move against the prolific Near Eastern fields. The second is the importance as soon as possible, of directing a sustained attack against Rumanian refineries which remain a chief reliance of the Nazis for those petroleum products which are essential to the successful prosecution of present day war.

Above: Oil train leaving Baku en route to Industrial Section.

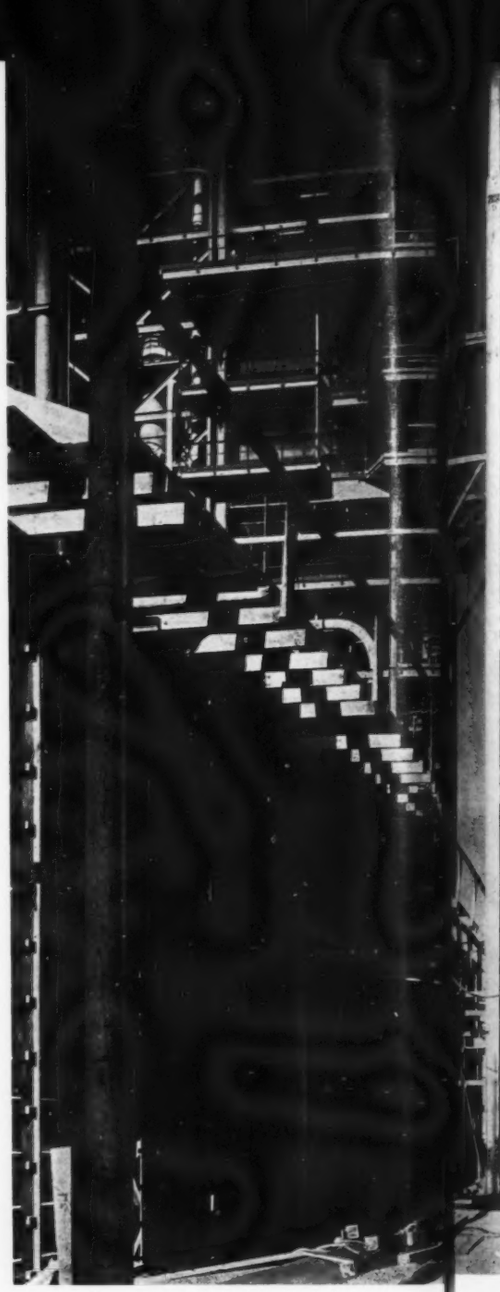
Left: Exterior view of Colombia Refinery in Rumania.

Oil Industry Has Met The Problem of

100 OCTANE GASOLINE

Increased Plant Capacity, Development of New Processes and Improvement in Methods and Results Have Kept Production Ahead of Requirements and Assure the Meeting of Greater Future Demands.

By Dr. O. W. Willcox



WHEN the complete history of the American Petroleum industry's part in World War II comes to be written, this industry will or should find itself credited with the performance of several near miracles of production in the service of the nation. One of the most notable of these performances is the creation of a great new source of 100 octane-number gasoline for the armed forces of the United States and allied nations.

In the kind of global warfare that is now raging, ultimate victory will perch on the banners of the side that is able to take and keep control of the air. The side that has the most and the best airplanes, and the most and best fuel for those planes will win. The designers and builders of American flying craft are furnishing the planes in the necessary numbers, and the petroleum industry is furnishing the necessary aviation fuel in the required quantity and quality. Possession of this combination of quantity and quality in the most crucial factor in modern warfare has already put the United Nations far above the Axis.

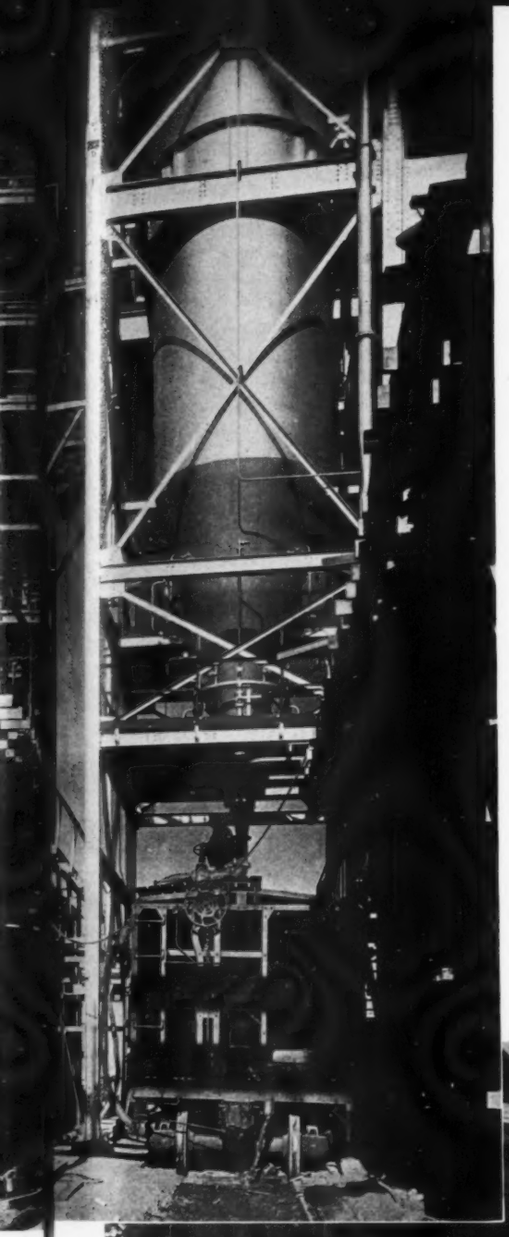
For meeting this responsibility nature has endowed the American petroleum industry with a nearly unlimited store of crude oil, which is one advantage that has been denied to the Axis. But to transform this bounty of nature into an overwhelming flood of 100 octane-number gasoline was no routine job. Industrially, 100 octane-number gasoline was still a comparatively recent development. When the collapse of France in 1940 revealed the danger that confronted the world's democracies this essential material for aerial warfare was being produced on a relatively insignificant scale, by processes that painfully extracted no more than three barrels of superaviation fuel from a hundred barrels of crude oil. Out of this nearly negligible nest-egg the American petroleum industry was scheduled to hatch an ultimate delivery of 250,000 or more barrels of 100 octane-number gasoline in every working day. For rising to that level of performance there would be required a vast amount of new construction to house newly designed equipment for working new or revamped processes. In the midst of this expansion of the aviation gasoline department the industry would also have to find the means for meeting greatly expanded needs for other indispensable military materials such as synthetic rubber, and toluene for explosives. At the same time the industry could not neglect its normal function of maintaining an adequate supply of ordinary petroleum products for military and essential civilian use. How to dovetail all these various operations in the most efficient manner was perhaps the hardest problem the industry had to solve; the solution of this problem of integrated operation on a grand scale is one among the claims of the industry to the thanks of the nation.

It should not be overlooked that in rising to the level of their responsibilities the members of the petroleum industry have done something more than make a show of technical skill and resourcefulness in attacking great and unfamiliar tasks. The occasion demanded a display of the higher qualities of team work and readiness to sink personal advantage and convenience in a genuinely cooperative effort to achieve the national purpose. The oilmen would perhaps never think of themselves as more patriotic than other American citizens who are throwing their all into the common war effort, but the record shows that they have not been behindhand of any. Of all the great basic industries that are sustaining America's might on the far flung battle fronts the petroleum industry is the one in which collaboration and integrated action have been developed to the highest pitch. The Office of Petroleum Coordinator, an office which is manned throughout by experts drafted from the industry, has well lived up to its name. Under the leadership of Coordinator Ickes the industry has willingly pooled not only its material resources and facilities but also its technical knowledge and "know-how." In this national emergency no other American industry can show a more consistent record of pulling together.

This pooling of material and intellectual factors has now proceeded to the point where no group in the petroleum industry is monopolizing any resource, patent, process, or position that would give it a competitive advantage over any other group engaged in the common task of defending the nation. Raw materials, sources of crudes, essential equipment, means of transportation, terminal facilities, and technical information of all kinds, have all been piled into a common stock from which every unit of the industry, great or small, may draw what it needs for playing its part in the job that has been set for the whole industry. The petroleum industry now has, in fact, practically attained a state of coordination so that it can and does bring its whole resources to bear on any or all of the numerous exigencies that arise to confront it.

The Army and the Navy have acknowledged that every demand which has been made upon the petroleum industry for delivery of petroleum products, including 100 octane-number gasoline, has been met fully and promptly. Not a single military engine of destruction or defense that the mechanical industry has got ready for use by the armed forces has yet lacked a full supply of fuel and lubricants of top quality. In the face of demands and estimates that have taken on astronomical proportions no bottlenecks have arisen in the petroleum industry to impede the prosecution of the war. With the industry coordinated as it is, and infused as it is with the spirit of cooperation for victory, there is little or no likelihood that any bottlenecks will arise from lack of know-how or engineering skill; the only thing that could throw the industry off its course would be failure of the WPB to allot the necessary materials and facilities.

It was in May, 1940, that the President of the



United States issued a first call for the nation to arm itself, and announced a program for the construction of 50,000 airplanes for the Army and Navy. The OPM was created, and its Petroleum Unit, under Dr. Robert E. Wilson, began to analyze the prospective requirements of the armed forces and the country as a whole for petroleum and its various products, under different defense programs and possible war situations. These requirements were then compared with the ability of the industry to produce, refine and transport the products that would be needed. The results of this comparison were reasuring. After allowing for a normal increase of the total domestic requirements and supposing that the nation would become involved in an all-out war that would impose a further increase of 5 to 10 percent on the existing requirements, it was seen that the petroleum industry could easily deliver the estimated quantities. There was a large available reserve of shut-in crude production, accumulated under a program of conservation practices and proration. Simply by opening up this reserve production it would be possible at once to make a 30 percent increase in the amount of crude oil flowing from the wells, and this could be kept up for two years without any major new discoveries or any unusual amount of drilling.

The refining branch of the industry was also found to be capable of immediate expansion. There was a large amount of shut-down refining capacity which was actually greater and more efficient than the entire refining equipment of the entire industry during the last war. With a little reconditioning this shut-down refining capacity could be set to work on the available shut-in produtcion and refine 1,000,000 more barrels of crude a day than were then being processed. The pipe lines could easily handle 20 percent more crude oil and manufactured products than were then flowing through them. The only possible bottleneck that could be foreseen was the one that subsequently developed in tanker transportation from the Gulf Coast to the East Coast.

This view of America's preparedness in oil seemed quite reasonable in view of the situation of the Axis powers in Europe. It was pointed out that the entire military activities of Germany and Italy, plus the industrial and other activities of those countries and in the occupied areas of western Europe, were being carried on with an amount of natural and snythetic petroleum products which is only about 5 percent of present American daily production.

The situation as regards 100 octane-number gasoline, which had begun to loom as a special element of the military supply problem, could also be regarded as satisfactory at that time. By the end of March, 1941 the Army-Navy Aero-

Left: Carload of finely powdered catalyst being unloaded from freight cars into hopper. Below: High altitude test room at Standard Oil Company (N. J.) laboratories. Photos by Robert Yarnall Richie for Standard Oil Company (N.J.)

Alkylation plant being constructed to meet the ever-expanding demand for 100-octane aviation gasolines along many war fronts. Photo by Robert Yarnall Richie for Standard Oil Company (N.J.)

nautical Board, after figuring in all present and foreseeable needs, had come to the conclusion that all military requirements would be covered by a production schedule of 24,000 barrels of 100 octane-number gasoline a day. Facilities then in existence for the production of this aviation super-fuel were seen to be adequate to produce at least double the quantity required under this schedule. A committee of the API had also made an inquiry into the ability of the refining industry to produce 100 octane-number gasoline. As of March 1 about 15 refineries were producing high grade blending agents, consisting of hydrocodimer and an alkylate, at the rate of 20,000 barrels a day, which with the base stock then available in large quantities would produce 40,000 bbl. per day of 100 octane-number gasoline. This supply could be doubled within 12 to 14 months by investing about $30,000,000 in new alkylate capacity. For this raising the outturn to 40,000 bbl. per day no new sources of base stock would have to be created.

The situation, up to the middle of 1941 then was that the petroleum industry had gone far ahead of the military authorities in the matter of anticipating the requirements for 100 octane-number gasoline. In retrospect it seems as though the refiners had sensed what was coming and from their own resources had instinctively begun to prepare for it. At any rate, on their own motion, and without any financial assistance from the government, and without a definite promise of orders, more than a dozen refining companies had installed and were operating commercial installations for the production of this high grade aviation fuel at a rate that was much in excess of the demand. For the excess of the unwanted product they were building, on their own account, storage which already held a huge reserve supply. One company alone, which was producing about 25 percent of the entire output of 100 octane-number gasoline in the country, had more of this product in storage than the whole reserve of the Army and Navy combined. In early 1941 the Army and Navy let contracts for a million barrels of this fuel. The industry had accumulated a total stock of aviation gasoline amounting to 6,348,000 bbl., which was 2,000,000 bbl. more than was on hand on the same date in 1940.

During this period, instead of the government prodding the industry to prepare, the industry was prodding the government to make the most of the present situation. The industry had the capacity to produce much more 100 octane-number gasoline than the government was taking, and was actually piling up a reserve that was crowding its own expanding storage facilities. For quite understandable financial and commercial reasons the industry could not continue to extend itself indefinitely. By the Army and Navy Aeronautical Board's own estimates as of March 1, 1941, the air forces then in contemplation would need 8,660,000 barrels of 100 octane-number a year. The military authorities might have done well if they had taken advantage of the industry's excess capacity to build up a large reserve stock in addition to what the industry itself was accumulating.

The military authorities were more or less favorable to this proposition, but OPM, which then was in principal charge of the defense effort, had its own ideas of where the available strategic materials would do the most good. The construction of additional storage of 100 octane number gasoline on government account was not approved, and the matter was left in abeyance for the time being. The current policy of the OPM in regard to materials also was holding down new construction by the oilmen themselves, who were not permitted to build as fast as they would like. They had already overbuilt their facilities for producing 100 octane gasoline and were producing more of it than their market would take, and they were still besieging OPM with requests for materials with which to build more facilities. The reason for this seeming excess of zeal appears to have been that the oilmen had a more comprehensive feeling of what was to come than was being entertained by the authorities. The oilmen may not have had a more definite conviction that the country would eventually be drawn into the war; it may merely be that they drew clearer inferences from the visible facts. The original program for 50,000 airplanes was followed by another calling for building 200,000 airplane engines, and plans for greatly expanded airplane production were known to be in preparation. The Lend-Lease policy would surely open the resources of the United States to the nations that were resisting aggression. These implements of aerial warfare would surely require amounts of fuel beyond the first estimates.

Expectations of a vast increase in the demand for 100 octane gasoline were not long in being fulfilled. The British Petroleum Mission arrived in this country on Lease-Lend business and it was seen that the requirements of British military aviation would have to be added to those of the United States. In June 1941 Hitler launched his prodigious assault on Russia, and Russian requirements were added to those of the United States and Britain. Large consignments were taken from the industry's reserve and started toward both these belligerents. At this time the oil industry, for reasons not of its own making, had not expanded its capacity for producing 100 octane gasoline beyond the 40,000 bbl. per day it had on March 1, 1941. The military authorities now revised their estimates of what was needed and in August 1941 requested the industry to double its production of this fuel, raising it to 80,000 bbl. per day. Members of the industry were ready to do what was wanted if they were allowed to obtain materials for construction.

By October 1941 the authorities became much more alive to the necessity of immediate expansion of the production of 100 octane gasoline and began to talk of trebling it to 120,000 bbl. per day. Storage stocks were falling behind. Airplanes were coming off the assembly lines at a rate that promised early absorption of the proposed increase in the supply of fuel, and together with the outflow of shipments on Lend-Lease threatened to create a shortage of 40,000 bbl. per day by January 1, 1942. New construction had to be rushed, but there was yet no indication that the industry would be unable to meet the demand on its own capital responsibility. An investment of $150,000,000 for 50 new units would be needed, and this investment was readily undertaken with the help of loans and contracts arranged through the OPC, which also assisted in formulating operating plans. At last, refineries were given the high priorities they needed for doing their job. By December 7, on the eve of Pearl Harbor, the stocks of aviation motor fuel were still above 7,000,000 bbl.

With the entry of the United States into the World War the industry and the authorities interested in 100 octane gasoline got down to business in an all-out fashion. From this time on the only thing that mattered was production, assured production. The original goal of 40,000 bbl. per day was now ordered trebled to 120,000 bbl. per day. Two months later the goal was lifted to 180,000 bbl., and a few weeks after that to 250,000 bbl. The oilmen were told to provide the necessary facilities quickly, and to do it more quickly than anybody thought it could possibly be done. There was to be no more debate over plans and processes, and there was no lack of funds. For the first time the government planked down its own money for creating facilities for manufacturing 100 octane gasoline, though private capital was still allowed to help. Refining companies were divided into three categories: those who could finance new construction with their own means, those who could finance only a part of the needed outlay, and those who needed full assistance. All who were able to participate were assured of firm contracts that would enable them to amortize their investments within a few years. All were given an invitation to participate; the government was ready to finance any reasonable proposition. Acceptable propositions quickly came in, and within two

months after Pearl Harbor the program for producing 250,000 bbl. per day or more of 100 octane gasoline began rapid strides toward fulfilment.

There was now no lack of financial means for producing 100 octane gasoline; the only question was whether the petroleum industry could organize its production on the required scale without upsetting the performance of its other functions; and particularly whether the industry could win the race against time. It has done both. At this writing the program is very far ahead of what could have been expected just a year ago. The way in which this near miracle was performed reflects credit on the industry's technical and organizational resourcefulness, and particularly on its patriotic spirit of cooperation and team work. The oil men knew the "how"; they also had the "will" which in all emergencies is the principal ingredient of success. When the first call was made for increased production of aviation super-fuel the art of refining had been developed to the point where 100 bbl. of crude oil could be made to yield about three bbl. of 100 octane-number gasoline. From the industry's preexisting groundwork of research and experiment the oil technologists expanded this more than threefold. It soon became standard practice for a refinery with a throughput of 50,000 bbl. of crude a day to deliver 5,600 bbl. of 100 octane gasoline, and even this is on the way to be tripled. In the new plants especially designed with a view to the exigencies of the present emergency, employing new arts of thermal cracking, catalytic cracking, isomerization, alkylation, precision fractionation, etc., as much as 30 bbl. of aviation super-fuel may be obtained from 100 bbl. of crude oil. With such intensely developed resources of oil technology the obstacles of time and material shortages have been largely brushed aside; the gigantic task of increasing production of 100 octane gasoline from 40,000 to 250,000 bbl. per day has been brought close to accomplishment "quicker than anybody thinks possible." And all the while the refining industry was addressing itself to the huge synthetic rubber program, and was forced to make radical readjustments of its production schedules to keep a balance between categories of essential products.

This outline of the oilmen's achievement in the struggle for more octanes must be complemented by a reference to what may be called their frame of mind, or attitude, which has been one of thoroughgoing cooperation and a will to victory. They have made a notable display of teamwork, with all members of the team throwing in what they had. There are now no trade secrets to limit the industry's war effort. All patents and processes, published or unpublished, that have any relation to the task that has been laid upon the industry have been made completely accessible, without royalty, to every petroleum enterprise that is in any position to make a contribution to the common aim. The big companies as well as the government have left little or nothing undone to see that every possible material and intellectual resource is made available for use by all.

One of the nation's new cracking units, known familiarly as the "cat cracker" which will utilize the fluid catalyst process being widely adopted in war petroleum plants to augment the supply of base stock and synthetic blending agents needed to make aviation gasoline. Photo by Robert Yarnall Richie for Standard Oil Company (N.J.)

As the progress of the war opens new panoramas and unfolds new fields of air, land and maritime operations it becomes evident that past demands for that all-essential product, 100 plus octane gasoline, are likely to be dwarfed by future requirements. But this prospect no longer worries the members of the refining industry. Even the much discussed program for building huge cargo carrying planes, those leviathans of the air that consume unprecedented quantities of high test aviation fuel, is view with equanimity. The oil men have gotten into the swing of this kind of production. The are supremely confident of their ability to show progressively better results and to shoulder whatever extra burdens may be imposed—provided that Washington acts in due time to provide the engineering materials that will be required.

PIPE LINES AND WAR DEMANDS

By J. R. Parten

Director of Transportation
Office of Petroleum Coordinator

Transformation of System for Moving Oil Eastward Has Involved Reversal of Flow, Relocation and Construction of Thousands of Miles of Pipe Which Will Raise Daily Movement to 500,000 Barrels.

WAR demands have taken from our shores most of the tank ships which in peace time furnished the major part of our petroleum transportation, measured in ton mile deliveries. The Pacific Coast has been affected, but because of shorter distances and lesser volume, it has not been affected as violently as has the East Coast. The normal East Coast delivery route of some 2,200 miles, together with a required daily delivery of something of the order of 1,400,000 barrels, has presented the principal problem in our re-adjustment program.

We can best grasp the size of this East Coast problem by a realistic view of the volume and distance involved. If we forget about the normal ocean route and limit ourselves to the overland distance between the oil sources in the Southwest and the center of consumption on the Eastern Seaboard, we are dealing with a distance of some 1,500 miles. If we apply to this mileage the objective volume of 1,400,000 barrels of petroleum per day, or some 200,000 tons per day, we have before us a movement approximating 300,000,000 ton miles per day. Expressed another way, it is a petroleum movement in excess of two billion barrel miles per day. To substitute overland means for such a movement that was normally nearly all ocean, has of necessity, heavily burdened both the resources and the ingenuity of a great industry.

Naturally, we have turned to tank cars, tank trucks, barges, and pipe lines as the expansible methods through which to accomplish this transformation. During the past six months, in the selection of methods, the expansion of which would best serve our objective, many controversial questions have had to be resolved. We have employed certain fundamental principles in appraising these methods. We have applied the rules of the least time required and the least expenditure of critical materials. In an expansion of facilities, we have recognized that more tank cars would require more locomotives; more barges would require more power boats, more canals and canal improvements; more pipe lines would require more available power; more tank trucks would require more rubber and manpower.

Paper presented before the Division of Production, Twenty-Third Annual Meeting of the American Petroleum Institute, Chicago, November 11, 1942.

We have been required, moreover, to weigh all of these in terms of steel and horsepower against the increased building of tank ships and related convoy equipment.

In our evaluation, we have related all of these methods of movement to a standard base route, long since used, from the Texas Coast to New York Harbor. Steel and power efficiencies became the controlling factors in our selection of the most desirable expansible method. We found in our calculations that over this base route we could depend on barges to deliver about 50/100 of a barrel of oil per day per ton of steel. Tank cars would deliver 52/100 of a barrel of oil per day per ton of steel. A large pipe line, the 24-inch, basis 300,000 barrels per day would deliver about 82/100 of a barrel of oil per day per ton of steel. At a stepped-up capacity of 450,000 barrels per day, this line would deliver 120/100 barrels per day per ton of steel

It was found that while the tank ship was about equal to the large pipe line, in steel efficiency, the convoy equipment required and other uncertainties governing tanker availability removed this method from consideration. It was found that tank trucks could make their best contribution as a substitute for tank cars on the short hauls, leaving the cars available for the long East Coast movement.

From a standpoint of power, a large pipe line stands out as the most efficient method for long distance movement. While more barges have been made available within the limits of existing power equipment; and while the effectiveness of tank cars has been greatly increased by methods to speed up turn-around; and while increased pipe line movements have been and are being accomplished by re-arrangement of existing pipe lines; it became obvious some time ago that one or more large pipe lines to the Eastern Seaboard was a vital necessity.

I do not need to emphasize the important part which has been played by pipe lines in the evolution of the oil industry. Commencing in the latter part of the 19th Century with a few short lines in Pennsylvania serving near-by refineries, the total mileage in gathering, tributary and trunk lines in the United States has grown to nearly 128,000 miles. The investment in these lines is approximately one billion dollars. Currently, there are some four million barrels a day of petroleum and petroleum products being delivered to refineries and terminals through these lines. This enormous volume of oil is moved underground invisibly and so quietly that we are prone to overlook the magnitude and importance of this mode of transportation.

Pipe lines in the past have been considered primarily as essential plant facilities for affiliated refineries in a highly integrated industry. Refining interests have almost always supplied the initiative and the capital for the construction and extension of pipe lines. They have done this in order to assure adequate supply of crude oil to meet manufacturing requirements.

With the advent of the war, however, pipe lines have assumed a greater importance in our national transportation system. Instead of serving essentially as plant facilities, pipe lines are now called upon to transport oil and its products over longer distances to meet military, industrial, and essential civilian requirements.

The whole pattern of our pipe line system has had to be changed in order to perform these functions. Nor has it been a matter of making a few changes: it has involved many re-arrangements and extensive construction and relocation. The program is well along the way toward completion and many alterations have already been made. But there still remains a great deal more to be done to accomplish our major objective.

I will not attempt to mention the many elements of this program to increase pipe line transportation. The oil industry and the Office of Petroleum Coordinator have worked together consistently to maximize pipe line capacity, making the greatest use possible of critical materials and manpower. Many proposals have been submitted, and numerous studies have been made in the endeavor to deliver by pipe line in the shortest span of time every barrel of oil possible to the places where it is needed most.

The large refining centers east of the Rocky Mountains, as you know, are in the Gulf Coast, the Middle West, and the East Coast areas. During times of peace, most of the pipe lines in Texas carried oil in a southerly direction to the refineries on the Gulf Coast. Products were then shipped by tanker to the Eastern Seaboard. Pipe lines in Oklahoma and Kansas transported oil northeasterly to refineries in the Chicago-St. Louis area and products were manufactured and distributed in the Middle West.

Although a small volume of crude was moved to the Atlantic Seaboard by pipe line, most of the oil was brought there by tanker and refined for distribution along the East Coast. This general scheme of pipe line transportation is necessarily being rearranged. While some crude lines will still carry oil to the Gulf Coast, some of these lines have been taken up for use elsewhere and four others are being reversed for the movement of oil in a northeasterly direction. Many of the crude lines from the Southwest and Mid-Continent areas are being enlarged in capacity. Products lines have been reversed and others have been increased in capacity in order to provide the Atlantic Seaboard with supply.

A comprehensive pipe line relocation and extensive program was adopted by the Office of Petroleum Coordinator in the Spring of this year. The program called for the extension of existing lines, the reversal of others, the building of loops, the installation of additional pumping stations, and in instances, construction of new lines.

The plans called for taking up and relocating some 1,700 miles of second-hand pipe, laying a total of 2,357 miles of new line, reversing and converting 2,800 miles of other lines, and installing considerable pipe line equipment and storage facilities. The program called for maximum use of second-hand material. Recommendation No. 49 was issued on May 11, 1942, by the Office of Petroleum Coordinator, in order to further this program. Management and engineering sub-committees were appointed for each of several recommended projects.

Units of some of the projects have already been finished and placed in operation. Included among these are the reversal and conversion of a Texas Company pipe line between Port Arthur and Dallas; the reversal and conversion of the Keystone Line across Pennsylvania; the enlargement of the Shell Line from Wood River to Lima, Ohio; reversal of the Sun-Susquehanna Line from Cleveland to the Eastern Seaboard; and the enlargement of the Texas Empire Line between Tulsa and Chicago.

In California, the 24-26 inch Stanpac Natural Gas Pipe Line, extending from Kettleman Hills to San Francisco, has been converted to crude oil service. This line now provides transportation for 100,000 barrels of crude oil daily to refineries in the San Francisco Bay area. All of the projects under the relocation program were scheduled for completion before the end of the year, but delay in procurement of necessary materials will cause some of the completions to be made after the first of the coming year.

I should like to touch briefly on some of the projects which are now in the process of construction. Starting with products lines, we are increasing the capacity of the existing Plantation Line from Baton Rouge, Louisiana to Greensboro, North Carolina. In order to provide the line with sufficient supplies, we are building a 60,000 barrel feeder line from Houston and Port Arthur to Baton Rouge. We are also constructing an extension to this line from Greensboro to Richmond, Virginia, from which point petroleum products will be moved still further north and east by barge. The project will not only enable us to assist in supplying the southeastern states, but will also contribute 30,000 barrels daily to such points as Washington, Richmond and Baltimore.

A new line will soon be built across Ohio designed to deliver at Akron 15,000 barrels daily to the Sun-Susquehanna Line destined for the New York-Philadelphia area. Pending the completion of this Trans-Ohio Line, we are moving products to Toledo, then taking them by lake tanker to Cleveland, whence they are transported through the Standard of Ohio and Susquehanna Lines into Pennsylvania.

A products line across Florida, with a carrying capacity of 35,000 barrels daily, is being constructed. Pipe for this project was procured by taking up the American Liberty Line in Texas. The Florida Line will extend from Carrabelle to Jacksonville. Products moved through this line will be transshipped by barge from Jacksonville, principally for the southeastern states.

The new Sinclair Line across southern Pennsylvania to Steubenville, Ohio, is nearing completion. When this line is finished, it will carry products from west to east.

Another combination movement of products to the East Coast will be effected by reversing and converting to products a crude line between Port Arthur and El Dorado, Arkansas; reversing an existing products line between Port Arthur and Shreveport, Louisiana; building a short extension in northern Louisiana and connecting it to the Magnolia Line into El Dorado; and constructing a new 155-mile line from El Dorado to Helena, Arkansas. This system will provide a movement of 55,000 barrels daily. Products will be transshipped from Helena by barge and tank car to points farther north and east.

The Great Lakes Pipe Line Company in the Middle West is also planning to enlarge its line between Kansas City and Minneapolis, in order to provide additional quantities of fuel oil and gasoline for the Northwest area of District 2. A 60-mile 6-inch feeder line connecting three refineries in Oklahoma with the Great Lakes Pipe Line at Barnsdall, Oklahoma, is also under construction.

The looping of the Texas Line between Dallas and Stuart, Oklahoma has been completed. Other important crude oil pipe line projects now under construction include looping the Stanolind Line between Graford, Texas, and Healdton, Oklahoma; increasing the capacity of the Stanolind Line from Oklahoma to Chicago; looping the Illinois Line between Lima and East Sparta, Ohio; installing additional pumping equipment on the Buckeye Line across Ohio; reversing the Tuscarora Line across Pennsylvania, and making numerous changes in other lines in New York State and Pennsylvania to increase the flow of crude oil to the East Coast. These changes are designed to deliver an additional 40,000 barrels daily into Chicago of which about 27,000 barrels daily will reach the East.

Of course, the 24-inch line from East Texas to Illinois and to the Atlantic Coast promises us the greatest measure of relief. This line stands out in our program and has challenged the interest of all pipe line engineers. It is the longest and largest pipe line ever constructed for the purpose of oil transmission.

The construction of such a line was advocated by Secretary Ickes more than two years ago. As the national emergency developed in the Spring of 1941, complete plans for the building of this line were crystallized. Unfortunately, due to the war demands, the material was not made available when first requested. However, as the need for additional transportation developed, the desirability and feasibility of the line became more firmly established.

Finally, in June of 1942, sufficient steel to build the line from East Texas to Southern Illinois was allocated by the War Production Board. Work was started immediately. Seven contractors undertook the building of this line in eight section spreads. Although many delays, such as those due to labor troubles, bad weather, and slow delivery of certain materials, have been experienced, progress has been fairly satisfactory. It is expected that the pipe laying between Longview and Norris City will be completed by December 10.

Analyses have been made which prove clearly that an extension of this line to the Eastern Seaboard is imperative, not only to supply essential domestic requirements, but to supply the off-shore demands of our armed forces. The Office of Petroleum Coordinator made a formal request of the War Production Board for the allocation of materials for this extension on October 6, and supported its application with the filing of a comprehensive report designed to justify this construction. The request of the Coordinator pointed out that in addition to the completion of this line, our office was convinced that it would be necessary eventually in the successful prosecution of the war, to lay another large pipe line from the Southwest to the Eastern Seaboard.

On October 27, the War Production Board authorized the extension of the 24-inch line to the Eastern Seaboard and allocated the necessary materials for this construction.

The War Production Board's Pipe Line Committee in its study of this problem in consultation with representatives of the Office of Petroleum Coordinator, recognized the probable necessity for a second large line and requested the Coordinator's Office for an additional report showing plans and factual justification therefor. It seems clear that if the war lasts, a second large pipe line to the Eastern Seaboard will have to be provided in 1943. In this case, of course, one of the lines will probably operate as a products carrier while the other will operate as a crude carrier.

The problem of supply for the War Emergency Line at Longview has presented several complications. The General Committees for Districts

(Continued on page 76)

UNIVERSITY OF TEXAS DEDICATES NEW PETROLEUM ENGINEERING BUILDING

State Institution Which Owes Its Great Endowment to Oil Completes First College Building in America Devoted Exclusively to Engineering and Research in Petroleum

By Ervin Hickman

APPROPRIATELY ENOUGH the University of Texas at Austin, Texas, which owes its endowment to oil, dedicated what is said to be the only college building in America exclusively devoted to the study of petroleum engineering, on October 29. The dedicatory ceremonies were held in connection with a meeting of the Gulf Coast section of the American Institute of Mining and Metallurgical Engineers. John R. Suman, president of the A.I.M.E. and vice president of the Humble Oil and Refining Company was one of the principal speakers and stressed the necessity of the conservation and wise use of the State's great mineral resources.

"Modern methods," he said, "have substantially eliminated the waste which would formerly have attended the production of Texas' vast store of oil, and so our reserve will serve mankind for a longer time. We wish to pass on our knowledge and skill, that you may start where we leave off, that you may succeed where we have failed. It is to this end that we lay this cornerstone in one of our great engineering schools, where you and your sons may learn to take a noble part in the great unfinished task we pass on to you. Give to your children more than we have given you, dedicate yourselves to maintaining our noble way of life, and then with pride, you will know in your hearts that in your land the blessings of freedom and justice will live on forever."

E. DeGolyer, Assistant Deputy Petroleum Coordinator was another leading speaker, discussing the importance of petroleum engineering and conservation. Other speakers on the program included President Homer P. Rainey, Dean A. P. Brogan of the University's graduate school, Dean W. R. Woolrich of the College of Engineering, Frank Buttram, president of the Independent Petroleum Association of America, and Dr. George H. Fancher of the University's petroleum engineering staff.

The new building, a three-story structure especially outfitted for petroleum engineering and research, is one of three buildings completed at the University this year. Placed in a box which was embedded in the cornerstone of the engineering building were letters from all speakers on the dedicatory program, from Dr. W. J. Battle, veteran University of Texas professor and former president, who is now chairman of the faculty building committee; W. R. Boyd, Jr., president of the American Petroleum Institute, E. L. Smith, president of the Texas Mid-Continent Oil and Gas Association, and from Col. Ernest O. Thompson, chairman of the Railroad Commission of Texas.

Added to the collection were a piece of core recovered from the Stanolind Oil and Gas Company Hulen No. 3, Alto Loma, Texas, at 10,040 feet; a drilling mud sample from Hastings field, Texas, and an oil soaked set screw and splinter from the derrick of the University discovery well on University of Texas property in the big lake oil field, Reagan County, Santa Rita Well, No. 1, discovered May 27, 1923, and crude oil samples from West Columbia field, Brazoria County.

The department of Petroleum Engineering at the University of Texas covers a wide field. The course in petroleum has been designed to give fundamental training in the application of mathematics, physics, chemistry and geology to development problems, and to the production, transportation, measurement, and storage of petroleum, natural gas, and natural gasoline. The curriculum provides for a course of four years and one summer leading to the degree of Bachelor of Science in Petroleum Engineering, with an additional year of post graduate study leading to the degree of Master of Science in Petroleum Engineering. The courses include petroleum engineering problems, petroleum production methods, production engineering, petroleum engineering laboratory, petroleum engineering design, prospecting methods, production engineering; oil field problems, natural gas engineering, petroleum economics, inspection trips, advanced petroleum engineering laboratory, fluid reservoirs, and research problems as well as volumetric and phase relationships of oil and gas mixtures. The last mentioned course is to be offered for the first time in 1942-1943.

This year 125 students are enrolled in petroleum engineering at the University of Texas. Sixty-five petroleum engineering degrees were conferred during each of the years 1939, 1940, 1941, and 56 in 1942. Since the department was established in 1930 the number of degrees has been 351. Of these 20 have been master's degrees. The three-story building has a process laboratory extending up through the first and second floors where heavy field and refinery equipment is swung up for study by means of a traveling carriage suspended from the ceiling. Large equipment need not be mounted permanently, but can be moved in and out, assembled or dismantled, to suit the occasion. On the second and third floors are natural gas, unit process, and other laboratories.

Several research projects are going on at the present time. One of the most important from the standpoint of its bearing on the war effort is that being conducted by Frazer Allen, holder of the Ethyl Corporation fellowship, on the deterioration of high octane gasoline under adverse storage conditions. Another project has just been completed in cooperation with the Bureau of Engineering Research on control of heaving shales which threaten drilling operations in certain parts of the state.

Approximately one-third of Texas' oil land income goes to A. & M. College and the remainder goes into the University's "permanent fund," a total of about $30,000,000. This must be invested since the University is only allowed to spend the income from this fund which amounts to about $550,000 each year.

Right: Gas laboratory in the new Petroleum Engineering Building.

Foreign Oil Legion

Professor Vladimir Nikolaevich Ipatieff

IN COMMEMORATION of his 75th birthday, Professor Vladimir Nikolaevich Ipatieff, world renowned chemist, and his wife were guests of honor at a testimonial dinner given by the Chicago Chapter of the American Institute of Chemists on November 20th at the Adventurers Club, Chicago. The occasion also marked the Golden Jubilee of the Professor's Career in Chemistry as well as the couple's Golden Wedding Anniversary. Dr. Gustav Egloff, national president of the American Institute of Chemists presided.

Professor Ipatieff is director of chemical research of Universal Oil Products Company. He came to this country twelve years ago, following a long and active scientific career in Russia. During his past twelve years in this country, Professor Ipatieff has continued his pioneering researches in Catalytic Chemistry. Many of the processes which he has developed have resulted in making available for war needs such vital materials as 100-octane aviation gasoline.

Dr. Fernand Holweck, director of research of the "Centre National de la Recherche Scientifique," and associate professor of physics at the Institute of Radium of the Sorbonne (Laboratory Curie), died in a Paris prison on December 14, 1941. Born in 1889, he was graduated from the School of Chemistry and Physics in Paris. He became assistant to Madame Curie in 1912, and from that time devoted all his activity to the Curie Laboratory. To geophysicists he is best known for the Holweck gravimetric pendulum which he perfected. At the beginning of World War II, and until the defeat of France, he was actively engaged in defense work and war inventions. Dr. Holweck had tremendous skill as an experimenter, and much important research was made possible by his uncanny ability to discover the way out of some technical bottleneck. It was a known fact that he had been experimenting with a special machine gun, and that the Germans wished to know something about his inventions is quite plausible. He died shortly after his imprisonment, although the exact circumstances of his death are not known.

Walter L. Faust, recently elected a Vice President of the Socony-Vacuum Oil Company, Inc. Mr. Faust joined the company in 1929, and since 1938 has been eastern Sales Manager in charge of Socony-Vacuum operations in the eastern part of the United States.

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"The Oil Problem of Latin America" was the subject of discussion at the meeting of the Latin American Economic Institute held at the Hotel Roosevelt, New York, November 19. The speakers of the evening were John D. Gill, of Atlantic Refining Company, and E. W. Mayo, Editor of WORLD PETROLEUM. Mr. Gill presented a comprehensive survey of Latin American production and consumption and pointed out the desirability from the point of view of these countries of early development of their latent oil resources. Mr. Mayo's talk was directed to emphasizing the possibilities and advantages of cooperation between North and South American interests in bringing about this development. Among the representatives of Latin America in attendance at the meeting were Jose Garrido Torres, Brazilian Government Trade Bureau, Rio de Janeiro, Lauro Guimaraes, "Sonalco," Rio de Janeiro, F. Petrinovic, Santiago, Chile, E. A. Canalizo, Mexico City and Dr. George Acuna, Costa Rica.

John D. Gill

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Confident that South America is going to offer an excellent market for post-war business, three western companies, the Willamette Hyster Company, Electric Steel Foundry Company of Portland and the Pacific Bridge Company of San Francisco, have engaged Samuel Haskell of Buenos Aires to carry on development work in South America. An American citizen, Mr. Haskell has resided in South America for the most part of the past twenty years and his work in connection with oil exploration and production has given him an intimate knowledge of South and Central America. While with the Andian National Corporation in Colombia he had charge of certain phases of the construction of a 356 mile, 10 inch pipe line from El Centro to Cartegena, Colombia, which was the first big pipe line built outside of the United States.

Left: Dr. Fernand Holweck
Right: Samuel Haskell

Wallace E. Pratt

Ralph W. Gallagher

Eugene Holman

STANDARD OF (N. J.) ANNOUNCES EXECUTIVE CHANGES

IMPORTANT CHANGES in the executive ranks of Standard Oil Co. (New Jersey) brought about by the company's age retirement requirements were announced by President Farish following a meeting of the Board of Directors, November 23. Retiring officers are Walter C. Teagle who resigned from his position as Chairman of the Board and director, E. J. Sadler and D. L. Harper, directors. The post of chairman is now filled by Ralph W. Gallagher who started with the company in 1896 and has been particularly identified with its natural gas and oil producing interests serving for several years as president of the East Ohio Gas Company. He has been a member of the Board since 1933.

Succeeding Mr. Gallagher and Mr. Sadler as vice presidents are two other directors, Wallace E. Pratt and Eugene Holman. Two newly elected directors are Frank W. Pierce, formerly executive assistant to the president and R. T. Haslam, previously in charge of research and engineering and more recently general manager of domestic sales. In announcing the above changes President W. S. Farish said:

"The influence which Mr. Teagle had on the development of the Standard Oil Company in the twenty years he was president cannot be measured by its expansion during that period. It was most significant in the changes which he effected in the relationship between management, stockholders and the large body of employees. He was personally responsible for the institution of a new basis for dealing with employees under which we had collective bargaining in this company many years before it was incorporated into national legislation. I believe it is the consensus of the people in our business that Mr. Teagle has made more of a contribution to the present form and successful operation of the American petroleum industry than any other man living.

"It is significant that the careers of the two men elected to replace the retiring directors symbolize the pioneering development of the company during the past two decades in two fields of management. One of these is labor relations. The other is oil chemistry.

"It was in the early days of Mr. Teagle's administration that many of the company's present policies affecting employee thrift plans, insurance, sickness and accident benefits, shorter hours, etc., were initiated. Mr. Pierce, who joined the company in 1924 as assistant to the manager of industrial relations, has played a vigorous part in the development of this program.

"In 1927 there came into our hands the challenging discoveries of German scientists in the field of hydrogenation and catalytic chemistry. American research engineers immediately started on a program of rapidly expanding application of these discoveries to the chemistry of oil. Out of this program have come better and cheaper lubricating oils, synthetic toluol, 100-octane gasoline, synthetic rubber and many other products crucially important to the winning of the war and full of promise for the post-war period. Mr. Haslam, who left the faculty of Massachusetts Institute of Technology in 1927 to come with Standard Oil Company, has been closely associated with these developments—first as an officer of the Standard Oil Development Company and later as general manager of domestic sales."

Frank W. Pierce

Walter C. Teagle

R. T. Haslam

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WORLD PETROLEUM ABSTRACTS

Summaries of the Most Important Articles as Published in the Oil Press of the World Dealing with Technical and Economic Aspects of the Petroleum Industry — Edited by Dr. O. W. Willcox.

DRILLING

The Daily Cost of Operating a Rotary Rig—Editorial in DRILLING, Vol. 3 (1942), No. 8, pp. 16-17.

From a number of answers to a questionnaire sent to drilling contractors with a request for statements of the daily cost of operating a rotary rig, two are selected as typical. Case I represents a heavy diesel rig powered with 450 H.P. in West Texas. The costs in this case are based on 5,800-ft. rock bit wells in wells in a Permian Basin area. Case II shows the average daily operating cost of several 8,500 ft. holes drilled with heavy steam equipment.

The costs shown in these tabulations are based on "paid days" and not simply on drilling days. During delays such as may be entailed by fishing jobs, the general expenses of the job go on as usual. An item which it seems is not included in the expense list of some contractors, and which some producers fail to appreciate is depreciation. The attitude in this matter seems to be that the rig would wear out anyway and it need not be taken into account; but sound business requires that it be given due weight. Another fact in the drilling business that seems to be widely overlooked is that the deeper the hole the greater is the average daily cost, as may be seen by comparing Case I and Case II. It is noted that no answer was received that did not show an average cost of more than $500 a day.

CASE I

Account	*Average Per Operating Day*
Compensation Insurance and Taxes	$ 16.83
Labor and Supervision	134.40
Auto Expense	5.00
Hauling	11.57
Pits and Cellar, Derrick and Lumber	20.45
Mud	7.43
Fuel	20.95
Bits	66.76
Supplies	43.62
Wire Line	4.72
Oil and Greases	5.60
Fishing	7.82
Fire Insurance	2.22
Shop Work and Repair	13.19
Administrative and Overhead	51.05
Depreciation	111.04
	$522.65

CASE II

Account	*Cost Per Operating Day*
Compensation Insurance and Taxes	$ 18.07
Labor and Supervision	132.91
Auto Expense	5.00
Hauling	37.38
Pits, Cellar, Derrick and Lumber	49.07
Mud	19.92
Fuel	29.27
Water	12.78
Bits	46.51
Supplies	52.45
Wire Line	16.72
Oils and Greases	8.03
Fishing	20.06
Fire Insurance	1.45
Shop Work and Repairs	29.60
Administrative and Overhead	54.86
Depreciation	123.67
	$657.75

Thermal Characteristics of High-Temperature Oil Well Cements—E. Byrd and F. W. Jessen (Humble Oil and Refining Co., Houston) in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 34, (1942), No. 10, pp. 1142-1148.

The total heat of hydration up to the time of the final set for five high-temperature oil well cements has been determined at temperatures of 150°, 175°, and 200° F. The chemical composition, fineness, presence of additives, and temperature are all factors which determine the total heat evolution from a cement until the time of its final set. The setting times and quantity of heat liberated by cements containing no additives are large-

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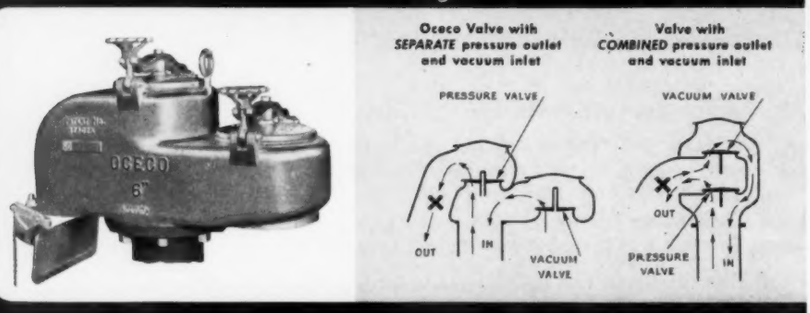

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● Laboratory tests and many tank fires have shown that when vapor passing outward through a vent valve becomes ignited—the flash (if no flame arrestor is used) can pass back into the tank if the velocity of the flash is greater than the velocity of the vapor flowing outward past the valve. The only positive protection against flash-back is an adequate flame arrestor . . . But if you don't use a flame arrestor be sure to specify an Oceco Vent Valve. It's the next best thing.

As shown by the diagram above, a flash of vapors leaving the tank at point marked X in Oceco's separate outlet valve, tends to close the pressure valve without opening the vacuum valve. In the combined outlet valve design, the flash has maximum opportunity to open the vacuum valve and find easy entrance into the tank.

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ly dependent on the chemical composition and fineness of the grind.

Consistency measurements at elevated temperatures provide a means of predicting the rate at which a cement slurry will attain its initial set. The admixture type cements have lower consistencies and remain pumpable over a longer period of time than do the nonadmixture type cements. Wide divergence in the heat evolution of the various cements leads to the conclusion that reactions accompanying the hydration of cement at elevated temperatures result in the formation of compounds quite different from those formed at lower temperatures.

A Review of Recent Advances in Drilling-Mud Control—Preston E. Cheney, before Production Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

The technique of mud control has made great progress under the hands of research engineers of the oil industry, university workers and experts of the commercial mud and chemical companies, who are more or less able to predict the response of mud to various treatments and how to avoid as well as to correct trouble. On the other hand the field mud engineer often does not have the opportunity to study the literature and to make experiments on the practical field application of new discoveries. The practical man is therefore inclined to regard the research man as too theoretical, and the research man regards the field man as unwilling to accept new ideas.

This paper is an attempt to bridge this gap between laboratory and field practice. The ordinary mud troubles are listed and described, and explanations are given as to the theoretical cause and the effects of the corrective chemical treatment. A feature of the paper is a table showing the combinations of mud properties, or the "symptoms" associated with each type of mud trouble. Opposite each "symptom" is an outline of the proper corrective treatment. This should be a help in reaching prompt decisions as to causes and remedies. The suggested methods of mud treatment have been used successfully and economically in the field.

Hydration-Pressure Relationships in Clays and Heaving Shales—H. H. Power, Barnaby L. Towle and Joseph B. Plaza, before Production Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

This paper reports a research to throw light on the subject of heaving shales, which are shales that tend to swell and expand into the drill hole when wetted by water from the drilling mud. In the act of becoming wet certain materials contained in the heaving shale become hydrated, or combined with water. A result of this hydration is that the clay particles swell enormously in volume, sometimes to nine times the original size. In thus increasing its volume the hydrated clay, if confined, may exert a pressure of several hundred atmospheres; under this pressure the hydrated clay, or clay gel, may thrust itself into the hole a large distance above the point of entry, and the pressure may be so great as to crush casing. It is therefore desirable to learn as much as possible about this material.

The authors experimented with a Wyoming bentonite containing about 90 per cent of montmorillonite, and heaving shale from the Hackberry field in Louisiana. Pressure as high as 4,700 pounds per square inch was observed in one case.

OPERATION

Prediction of the Shrinkage of Crude Oils—D. L. Katz, before Production Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

Crude oil in a natural reservoir under pressure contains dissolved gases; and, as the crude oil travels from the reservoir to the lease storage tank, the volume of the oil decreases. One barrel of oil in the lease tank may require 1.2 bbl. of reservoir fluid to be produced from the reservoir. The reduction in volume of the reservoir fluid caused by reduction in temperature and by the liberation of the natural gas as the pressure is decreased has been described customarily as the shrinkage of the oil. Laboratory measurements are made of this gas-liberation or shrinkage process to give the actual shrinkage values to be used for specific reservoirs. However, in many cases a particular engineer may not have available the shrinkage data for a given reservoir, and it may be necessary for him to estimate this shrinkage. Any computation of oil and gas reserves must include a shrinkage factor to convert reservoir oil to stock-tank oil.

Recent information on the methods of computing the density of liquids containing dissolved gases makes possible more accurate calculation of phase behavior under pressure for crude-oil-natural-gas systems. There are five methods of predicting the shrinkage of reservoir crude oil when the dissolved gas is liberated which have been described for cases wherein experimental shrinkages were not available. These methods are of decreasing accuracy for decreasing amounts of information available to predict the shrinkage. The methods are: 1, computation of the shrinkage when the gas analysis of the liberated gas, quantity of liberated gas or solubility, saturation pressure, saturation temperature, and residual crude-oil gravity are known;

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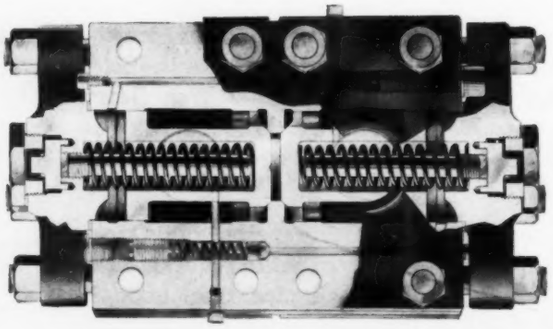

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2, calculation of shrinkage when the gravity of the liberated gas, quantity of liberated gas or solubility, residual crude-oil gravity, saturation temperature, and saturation pressure are given; 3, calculation of shrinkage when the quantity of gas liberated or solubility, residual crude-oil gravity, saturation pressure, and saturation temperature are known; 4, calculation of the shrinkage when the solubility of the gas and saturation or vaporization temperature are known; and, 5, calculation of shrinkage when only crude-oil gravity, saturation pressure, and saturation temperature are known.

The fourth and fifth methods may be 25 per cent or more in error.

PIPE LINES

An Analysis of Certain Circuits in Cathodic Protection—Gordon N. Scott, before Production Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

In seeking a solution to the troublesome problem of avoiding damage to pipe lines which lie adjacent to a cathodically protected pipe line, the author has found that a simple relationship exists between the concerned pipe lines in their ability to pass current through the wire bonding them together. This relationship resolves itself into a linear algebraic equation by which the external resistance of the circuit usually can be measured. This relationship has practical usefulness:

1. In designing a drainage bond, which is a wire connecting the two pipe lines, and controlling the amount of current passing between them.
2. In testing the efficiency of an insulated flange for current leakage to prevent consequent damage to the pipe.
3. In measuring the current density at which point the pipe becomes polarized to decide when sufficient cathodic protection has been applied to the structure to protect it.
4. In measuring the polarization as a test for the corrosivity of the soil.

Application of this principle of measurement, this algebraic equation, results in more useful information than ordinarily is obtained by an instrument designed for a particular measurement. For example, a potentiometer customarily is used to make a certain type of measurement on a pipe line. Applying the above-described relation in conjunction with a multi-range current-drawing instrument, not only gives the potentiometric reading, but also yields information on the resistance of the reference electrode used, as well as on the resistivity of the soil, and the total amount of current that can be drawn normally through a system. Understanding this relationship helps considerably to clarify the meaning of many other measurements which are daily made by workers in cathodic protection, and explains simply many problems and phenomena encountered in electrical protection of pipe lines.

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CHEMISTRY

Butadiene from Butylene Glycol—Albert L. Elder, before AMERICAN CHEMICAL SOCIETY, DIVISION OF PETROLEUM CHEMISTRY, Buffalo, September, 1942.

In a discussion of the present status of production of butadiene, mention is made of the production of butadiene by fermentation of grain.

Grain is fermented in the presence of aerobacter aerogenes until the reaction is approximately 90 per cent complete, which requires less than 40 hours. The difficult problem is the separation of 2,3-butylene glycol from the "beer." One method utilizes butanol as a selective solvent followed by separation of the butylene glycol, which boils at 180° C., from the butanol. It has been claimed that 2,3-butylene glycol can be pyrolyzed to give satisfactory yields of butadiene. Unfortunately, there is not complete agreement on this point. It is a fact that 2,3-butylene glycol can be esterfied to form the diacetate which in turn can be pyrolyzed at about 500° C. with the production of high yields of butadiene. By using only one pass through the pyrolysis chamber, followed by separation of the butadiene from the monoacetate, and recycle of the monoacetate an overall conversion of 88 per cent has been attained using pilot-plant equipment. Eight to ten of the remaining 12 per cent is accounted for as polymerized butadiene. With full size equipment the yield should improve. The only difficulties encountered in going through the diacetate process are those inherent in handling concentrated acetic acid, which requires some strategic materials. The butadiene obtained is unique in that it is of sufficient purity that it can be used without further purification in making synthetic rubber. It is estimated that 14-15 lb. of

glycol can be obtained from a bushel of corn. This should produce approximately 7 to 7.5 lb. of butadiene.

Photomicroscopy of Salt in Petroleum—Lloyd F. Christianson and J. W. Horne, in BUREAU OF MINES TECHNICAL PAPER NO. 638 (1942), 56 pages; 25 cents.

Heretofore, producers and refiners have considered that a chemical analysis of salts in crude oil gives adequate information for their desalting operations. Recently the Bureau of Mines has found that the physical state and behavior of such salts played an important part in desalting, and that it was desirable to supplement chemical analyses with knowledge of the physical form and dispersion of the salts that accompany crude oil. This physical examination can be made with a polarizing or petrographic microscope, and this technical paper shows how. It also describes the characteristics of brine emulsion of various origins, the effects of demulsifying chemicals, and how to determine the efficiencies of chemical preparations offered as demulsifiers.

It was found that the salt in the brine emulsion ultimately will precipitate as free or oil-coated microscopic crystals when the emulsion film has broken, or when other conditions exist that permit the water to evaporate from the brine. Therefore it was concluded from these observations that it is better to make one complete dehydration of the emulsified oil at the time of treatment than to allow opportunity for salt crystals to form from the partly demulsified brine. The examination of various emulsions showed characteristic differences due to salt content, manner of producing the oil, size of droplets, and stability.

Oil chemists having to do with salt water emulsions will find this booklet useful and informative.

Catalysis of Lubricating Oil Oxidation—R. C. Larsen and F. A. Armfield, Shell Development Co., Emeryville, Calif., before AMERICAN CHEMICAL SOCIETY, DIVISION OF PETROLEUM CHEMISTRY, Buffalo, September, 1942.

The catalytic effect of iron, copper, and lead in the bulk and dissolved form on three oils broadly representative of those obtainable from Pennsylvania, Mid-continent, and California crudes has been studied in detail. The variations in catalytic susceptibilities of the oils, as well as the variations of catalytic activities of the metals with concentration, are so great that it is concluded that no specified catalyst can be used in laboratory oxidation tests unless correspondence with engines is first well established.

In addition, the catalytic effect of engines on oils was investigated. It was found that the oil-insolubles (called crankcase catalysts) which accumulate in engine lubricants are extremely active catalysts. This catalytic activity resides in the metallic constituents, particularly the halides of iron.

Catalytic Vapor-Phase Alkylation of Benzene with Ethylene—W. A. Pardee and B. F. Dodge, before AMERICAN CHEMICAL SOCIETY, DIVISION OF INDUSTRIAL AND ENGINEERING CHEMISTRY, Buffalo, September, 1942.

For some time ethylbenzene, which figures as an intermediate in the manufacture of styrene for synthetic rubber, has been produced by reacting benzene and ethylene in the liquid phase in the presence of aluminum chloride as catalyst.

The material presented in this paper reports the results of research into the reactions of benzol and ethylene in the gaseous state instead of the previously mentioned liquid phase. Numerous catalysts to speed the reaction were investigated, as well as the effects of such operating variables as time, pressure and temperature, and excellent yields were obtained under certain conditions.

Lubricating Oil Detergency—S. K. Tadey and R. G. Larsen, Shell Development Co., Emeryville, Calif., before AMERICAN CHEMICAL SOCIETY, DIVISION OF PETROLEUM CHEMISTRY, Buffalo, September, 1942.

Four methods of evaluating the detergency of lubricating oils are described. One method involves a chromatographic procedure using lamp black, while the other three make use of centrifugal separation, filtration through an asbestos mat, and infra-red transmission, respectively, to evaluate the degree of dispersion of oil-oxidation products. All show useful correlation, within limits, with engine experience on detergency and, in addition, are useful tools in examining the detergent aspects of lubricating oils.

Ketones by Condensation of Acid Anhydrides with Olefins—A. C. Burns and T. F. Doumani, before

This Johns-Manville Coating and Wrapping Machine is being used on the

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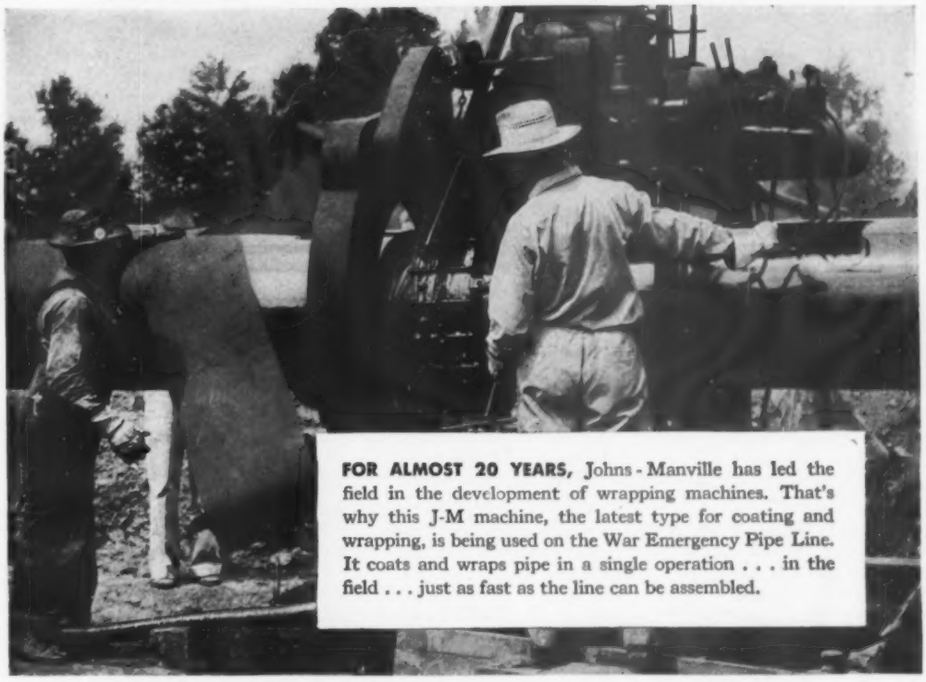

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ASBESTOS PIPE LINE FELTS

AMERICAN CHEMICAL SOCIETY, PETROLEUM DIVISION, Buffalo, September, 1942.

A simple method of building ketones (synthesis) by reacting small units (olefins) produced from petroleum by cracking, with an acid anhydride has now been found to proluce ketones which have interesting possibilities for utilization. To cause the interaction of the acid anhydride with the olefin, a third substance (a catalyst) must be used such as zinc chloride or sulfuric acid. This method may be extended to the reaction of various acid anhydrides with olefins.

PHYSICS

Correlation of Laboratory Oil Bench Tests with Engine Tests—C. W. Georgi, before SOCIETY AUTOMOTIVE ENGINEERS, Tulsa Meeting, October, 1942.

This is a report on a cooperative test in crankcase oil stability, involving the testing of six reference oils in the Underwood apparatus, Lauson single cylinder engines and in bench test apparatus of other types. The Underwood apparatus, when run for ten hours at 325° F. with 0.01% of Fe_2O_3 (as naphthenate) correlates quite satisfactorily with 36-hour Chevrolet engine tests on five of the six oils. This exception is of minor importance and a ready explanation is given. Like all other bench apparatus, the Underwood apparatus cannot be used to predict service performance without additional substantiating tests in engines. However, this apparatus is indicated as a very useful sorting device to differentiate the stability and corrosion properties of poor, mediocre and good oils, particularly as related to research and the development of improved oils and additive compounds. The operating conditions (given) should be observed.

The Lauson engine is a remarkably versatile oil testing device and with proper selection of operating conditions can apparently be made to rate oils as to their stability, bearing corrosion, detergency and ring sticking properties in line with full-scale engine tests. Test time, oil temperature and the temperature of the cooling medium are the most important variables. The report gives tables for Lauson operating conditions for evaluating oil stability and bearing corrosion tendencies, for evaluating detergency and bearing corrosion, and for an accelerated detergency test. As with other types of bench tests, Lauson engine tests must in the end be substantiated by tests on full scale engines.

Evaluation of Effective Displacement Pressures for Petroleum Oil—Water Silica Systems—Frank G. Benner, Charles G. Dodd, and F. E. Bartell, before Production Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

When petroleum is produced from a reservoir the pressure which drives the oil through the sand is frequently supplied by water. The completeness with which the oil is displaced depends on the relative abilities of the water and the oil to "wet" the sand grains. In this work it was ascertained that displacement to a large degree depends on the angle of contact between the three elements: solid, water, and oil. If this angle is less than 90 degrees, it may be said that water wets the rock material to a greater degree than oil, and *vice versa* if the angle is greater than 90°. The experimental work was done with artificial sand beds.

The fact that all of the crude petroleum oils investigated in the present work exhibited the phenomenon of hysteresis of the contact angle to a greater or lesser degree leads one to suspect that most crude oils contain surface-active constituents, i.e., heteropolar molecules or colloidal materials which become adsorbed at the interfaces. Adsorption of these materials alters the surface of the reservoir material, and it is this altered surface which underlies the advancing water. Advancing-water angles are, therefore, better criteria of the wettability of a reservoir material than are receding angles where the surface involved has not been in contact with the oil.

Probably the most significant fact brought out in this work is that so large a percentage of the oils gives advancing interfacial contact angles greater than 90 deg. This indicates that, in effect, the immobile surface underlying these oils is decidedly hydrophobic, and that water will not displace spontaneously the oil from such surfaces. This situation should receive further and detailed investigation. Of importance would be the determination of the relative amounts of oil which would be retained as adhering films by such surfaces during the process of water drive. It seems likely that the amount of oil retained would be related definitely to rate of drive.

It is probable that, in those systems in which the advancing angle is less than 90 deg., almost complete oil recovery would be possible, provided a suitable rate of drive were employed.

A knowledge of the magnitude of the interfacial contact angles of a given petroleum oil system should enable one to predict the ease with which displacement of the oil might be effected.

Addition to the water of even minute amounts of materials which would decrease the magnitude of the advancing interfacial contact angle to a value of less than 90 deg. might prove to be of tremendous aid in effecting oil displacement by water.

Composition of the Dew-point Gas of the Methane-water System—R. H. Olds, B. H. Sage and W. N. Lacey, in INDUSTRIAL ENGINEERING CHEMISTRY, Vol. 34 (1942), No. 10, pp. 1223-1227.

In nearly all cases petroleum reservoirs involve structures whose voids are partially filled with water. Therefore an understanding of this component in the phase behavior of the heterogeneous water-hydrocarbon mixtures becomes of importance. The available experimental information relating to the behavior of hydrocarbon systems and water at elevated temperatures is meager, and this paper aims at enlarging knowledge on the subject.

The composition of the dew-point gas of the methane-water system was determined experimentally at pressures from the vapor pressure of water up to 10,000 pounds per square inch in the temperature interval between 100° and 460° F. The experimental data were smoothed by suitable graphical methods, and the resulting values are presented in both tabular and graphical form. The results are compared with data for other systems of a similar nature and with predictions based upon an assumed behavior for the system.

The experimental results indicate that, although the weight fraction of water in the gas phase decreased with isothermal increase in pressure, nearly five times as much water was present in the gas phase at the higher pressures and the lower temperatures as would be predicted from simple vapor pressure considerations. This effect is large enough to be of industrial importance when hydrocarbon gases are in contact with liquid water at high pressures. Such situations occur at times in deep petroleum and natural gas horizons and in the processing of natural gas during high-pressure recycling operations.

Photoelectric Color II. A Study of Light Colored Petroleum Products—J. C. Dean, R. J. DeGray, and J. W. Wilson, Jr., Socony-Vacuum Oil Co., before AMERICAN CHEMICAL SOCIETY, DIVISION OF

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PETROLEUM CHEMISTRY, Buffalo, September, 1942.

The applicability of photoelectric color for the evaluation of light colored petroleum products has been demonstrated. Readings are taken with a violet filter and converted to photoelectric color or apparent brilliance by a suitable equation. I.C.I. data may be calculated from photoelectric color readings if desired, although this is usually unnecessary in petroleum technology.

The Saybolt Chromometer has been shown to be unreliable, and to be greatly affected by the surface tension, refractive index, and specific dispersion of the oil being tested. Photoelectric color may be converted to Saybolt color by the establishment of suitable curves for the types of product in question. The colorimeter used is easily standardized and the results obtained are independent of the particular instrument.

Asphaltic Substances in Crude Oil—S. W. Preckshot, N. G. DeLisle, C. E. Cattrell, and D. L. Katz, in PETROLEUM TECHNOLOGY, Technological Paper No. 1514, September, 1942, 18 pages.

Most crude oils contain asphaltic substances that may be naturally or artificially precipitated. In some cases, as in the Greeley field in California, this asphaltic bitumen is precipitated during the flow of the oil from the reservoir to the stock tank. The mechanism of this precipitation has heretofore not been well understood.

For a study of the phenomenon the authors employed the electron microscope. It was found that the problem is more closely related to surface or colloidal chemistry than to the usual phase equilibria. The study was then directed toward the electrical effects of fluids through porous solids, with emphasis on the formation of colloidal particles by the streaming potential. The streaming potential of crude oil flowing through sand was measured, and was shown to be responsible for the formation of bituminous particles. Parallel phenomena are likely to occur when crude oil flows through a porous reservoir rock.

REFINING

Corrosion Resistant Alloys in Natural Gasoline Plants—B. B. Morton, before CALIFORNIA NATURAL GASOLINE ASSOCIATION, August, 1942.

Natural gasoline plants are subject to several types of corrosion as a result of the presence of moisture, sulphur and salts in the materials handled. The problems met with are therefore varied, and they are complicated by material shortages; while these shortages cannot always be avoided, it is well to have information on the behavior of corrosion resistant materials.

Experiments are reported on the rates at which various metals were penetrated when all were exposed to identical conditions of experiment. Metals tested include mild steel, monel, nickel, inconel (75% Ni, 13% Cu), admiralty metal, cast iron, nickel-resistant cast iron (15% Ni, 6% Cu, 2% Cr), 18-8 stainless, 5% Ni-steel, 3% Ni-steel, 70-30 Cu-Ni, yellow brass, gray cast iron, 18-8-3 Mo stainless, 16-13-3 Mo stainless.

On a straight run, 63 A.P.I. gasoline, mild steel showed the worst performance with 0.021 inch penetrator; the next worst was admiralty metal with a penetration of 0.008 inch. The best was Ni-resistant cast iron (15% Ni, 6% Cu, 2% Cr).

In a test with a straight run gasoline plus hydrogen sulfide, mild steel was again the worst with a penetration of 0.0115 inch, the next worst was plain cast iron with 0.096 inch and the best was monel with 0.0015 inch; Ni-resistant cast iron was fairly close with 0.0025 inch. In this test it is noted that monel linings in the lower parts of the condensers gave good service where steel and 18-8 stainless were destroyed.

In a test with gasoline from the caustic mercopton removal unit contaminated with hydrochloric acid from decomposition of salts, mild steel was again the worst with 0.05 inch of penetration; 18-8 stainless the next worst with 0.0259 inch; yellow brass was almost as bad with .0024 inch. The best was monel, with 0.0075 inch. In this test gray cast iron was run for 90 days and showed 0.043 inch of penetration, which may be compared with 0.05 inch for mild steel run for only 60 days.

In a concluding test on a product with naphthenic acids in the distillate at 554° F. on a 60-day run, the worst was 18-8 stainless with 0.0236 inch, while 18-8-3 Mo stainless showed 0.002 and 16-13-3 Mo

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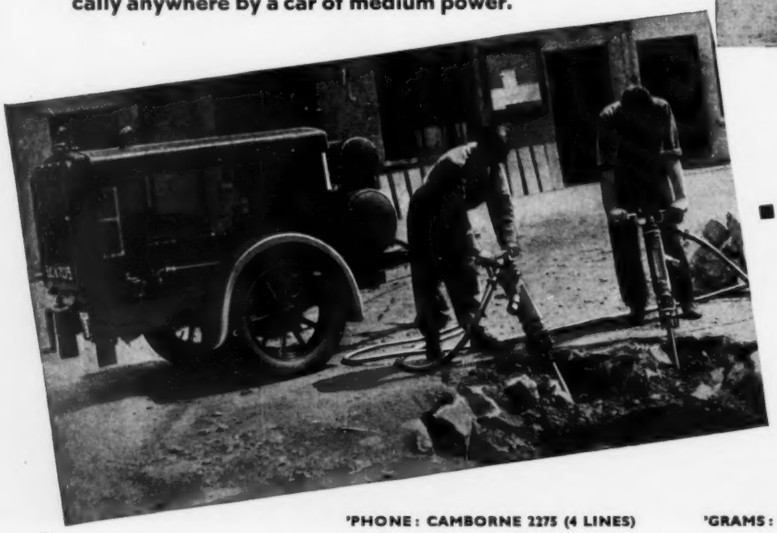

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stainless only 0.0009. Although the temperature was above the limit usually set for monel and nickel to prevent sulphur attack, these metals showed relatively low penetration (0.0012 and 0.0006, respectively).

From the experiments it seems that for these services 18-8 stainless is little if any better than mild steel where corrosive agents like hydrogen sulfide and hydrochloric acid or naphthenic acids are present. Stainless steels containing molybdenum give good accounts of themselves.

Trends in Centrifugal Pumps—Drew T. Whiting and K. P. Hurley, before WESTERN PETROLEUM REFINERS' ASSOCIATION, Shreveport, August, 1942.

Twelve years ago the toughest refinery pumping problem was recycling hot oil through cracking stills. About that time oil refineries began to change into the equivalent of great chemical plants, and a vast number of new processes with strange names appeared: catalytic cracking, alkylation, acid alkylation, isomerization hydroforming, polymerization, fluid catalyst, and others. All these new processes raised up new pumping problems, some of them quite unlike anything met with before in refineries, such as the circulation of large volumes of molten salts at high temperatures in certain catalytic processes. Another notable innovation in refinery pumping design is the use of large centrifugal blowers driven by hot gas turbines. New problems appeared when alkylation plants began to use hot sulphuric acid, both as to pump packing and the danger of fire resulting from cracking of cast iron, which was theretofore the standard material for hot acid pumps. All these problems, including those encountered in alkylation by the use of hydrofluoric acids, have been satisfactorily solved.

Some of the toughest problems were encountered in the manufacture of toluene, where great numbers of towers are required for close fractionation, and where large volumes must be moved at high speeds and under the temperature of hot oil service. Needless to say that careful design is needed, especially to prevent leakage. In some toluene plants where phenol must be repumped, a serious metallurgical problem is encountered and is only to be overcome by use of high Cr-Ni steels. The equivalent of the old-time hot oil pumps are put to severe use as charge and quench pumps in thermal polymerization plants, where they have to handle up to 1000 G.P.M. against extremely high heads in many stages (12 to 16). Such pumps must be built with great accuracy, with particular attention to the packing boxes. Another application of these high-pressure, barrel-type pumps is for handling lean oil in high pressure absorption plants in distillate fields.

In some departments, as in the new processes involved in continuous catalytic cracking, manufacture of buta drene, etc., there are special pumping problems that have not been completely worked out, and will need investigation. In addition to its oil pumping problems the refineries have had a large water pumping problem thrust upon them. The addition of so many new facilities calls for great additions to the cooling water supply, in some cases up to 100,000 G.P.M., with correspondingly large pumping and power generating equipment.

Critical Analysis of Sweetening Processes and Mercaptan Removal—John Hoppel, S. P. Cauley and E. S. Kelly, before Refining Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

In this paper the authors have two objects in view; one is to discuss the different types of gasoline purifying processes and the factors which should be considered in determining the applicability of a process; another is to show the saving—both in cost and in consumption of strategic chemicals—which could be effected by changing the mercaptan sulfur-content specification of gasoline.

In pursuance of the first of these objects they briefly describe the processes now mostly in common use. For convenient reference and comparison a large table is given from which the characteristics of these processes can be given at a glance. Data on the extraction and stripping coefficients with natural solubility-promoters extracted by caustic washing of cracked and straight run gasoline from mid-continent crude are given; also a method for calculating mercaptan removal with caustic solutions with or without solubility-promoters. Their general idea is to indicate how the refiner, by considering the characteristics of the various treating purposed and with a knowledge of the gasoline and other conditions at his refinery, may make a choice among these processes.

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The authors consider that the doctor test now lacks practical significance and should be eliminated. They also make the point that striving for very low final mercaptan-sulfur content may be more expensive than is necessary. They figure that the net cost (including TEL credit based on raw gasoline) when treating to 0.002 to 0.003 per cent of mercaptan sulfur may be one third less than when mercaptans are removed down to 0.0004 per cent (doctor sweet). In other words, the mercaptan content of treated gasoline as specified according to the doctor test (0.0004 per cent) is far too high. Gasolines with a mercaptan-sulfur content of 0.005 per cent and higher are being marketed and are declared to be satisfactory from an odor and corrosion standpoint.

Re-refining of Aircraft Engine Oils—Gilbert K. Brower, before National Fuels and Lubricants Meeting, SOCIETY AUTOMOTIVE ENGINEERS, Tulsa, October, 1942.

It is estimated that the consumption of aircraft lubricating oils will soon exceed 10,000 bbl. a day. The question of re-refining this oil is therefore of considerable importance from a conservation standpoint. Since aircraft engine oil must be of the highest quality a sharp distinction must be made between reclamation and re-refining. The former is a process which aims only at the removal of water and insoluble materials by centrifuging or mechanical filtration; this method leaves the oil contaminated with diluents such as gasoline and products of decomposition that are soluble in the oil.

The author draws on twelve years experience in re-refining the aircraft engine oils for a major air transport system, and describes various types of apparatus used for the purpose. Operations with the unit currently in use are conducted as follows: The used oil is mixed with an activated earth (Magnesol or Retrol, the latter being standard) and passed into an electrically heated still where it is steam stripped at a sufficiently high temperature to drive off moisture and diluents, keeping up the heating long enough for proper clay treatment. From the still the mixture flows by gravity through a heat exchanger to a mixing tank where a filter aid (Hy-flo super cel or dicalite) is added. It is then pumped through a plate and frame filter press, with the cloth backed up by a paper filtering medium. Still temperatures depend on the type of oil, kind of earth and condition of the drainings, and must be determined by trial. Usually, steam stripping is begun at 425° F., going to a maximum of 525° F. When the process is properly carried out (no acid treatment is allowed) the re-refined oils meet new oil specifications, additives being added if required.

Reduction of Ash Content of Residual Oil with Boric Acid—E. T. Scafe, K. F. Hayden and V. A. Kalichevsky, before AMERICAN CHEMICAL SOCIETY, PETROLEUM DIVISION, Buffalo, September, 1942.

A process developed in the laboratories of the Socony-Vacuum Oil Company employs boric acid at elevated temperature for removing the alkaline constituents of "soda tars" resulting from the distillation of crude oil in the presence of sodium hydroxide. The removal of these constituents is of considerable economic importance because it eliminates formation of alkaline ash which reacts with the furnace refractories causing their rapid disintegration.

In this new process, a mixture of soda tar and boric acid is vigorously agitated at about 400° F. under 250 pounds per square inch pressure and the reaction products are separated by settling. The boric acid may be recovered from the boric acid sludge for reuse in the process by simple acidification, crystallization and filtration. The method obviates the necessity of aqueous neutralizing reagents which have been proposed for this purpose, and which are generally considered impractical because of formation of emulsions between the viscous oil and water. In the boric acid process no emulsification difficulties are encountered because of the use of an anhydrous reagent in a molten state.

Boric acid does not react chemically with the hydrocarbon components of the oil. It is cheap and may be easily regenerated, which is important because fuel oil is not an expensive commodity and the application of costly refining methods is impractical. The use of the process will permit the refiner to produce high grade industrial fuel oils from inferior grade materials which may be now considered as a drug on the market and which can be disposed only in blends with other oils. The consumer will be likewise benefited by a reduced maintenance cost of his heating equipment.

Method for Analyzing the Gasoline Fraction of Petroleum—Frederick D. Rossini and associates, before Refining Division, AMERICAN PETROLEUM INSTITUTE, Chicago Meeting, November, 1942.

As a portion of the work on A.P.I. Research Project 6, which has now been proceeding for about fifteen years, the authors here outline a method for analyzing the gasoline fraction of petroleum with respect to the main hydrocarbon components, and they give preliminary results on naphtha fractions from East Texas and Oklahoma crudes, together with results of a test experiment on a mixture of seventeen known hydrocarbons (six paraffins, four naphthenes or cycloparaffins and seven aromatics) normally boiling in the range 60-174° C. In this method, the distribution of which is limited to appropriate groups, the aromatics are first separated by adsorption from the naphthenes and paraffins and both groups are then fractionated separately.

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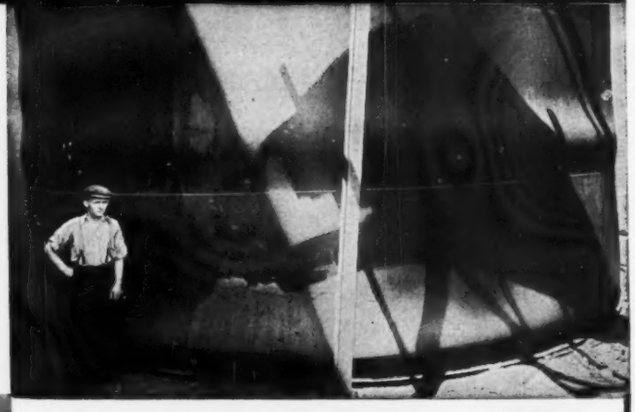
Proof of the soundness of Oxley welded construction lies in these photographs of tanks, subject to damage by enemy air attack.

In the upper photograph the depth of liquid in the tank was 37' 6" and, notwithstanding some distortion of the plates, there were no leaks at the welded seams.

In the second photograph the tank was severely damaged, but again the welds held on the distorted plates.

Both tanks have since been repaired by Oxley.



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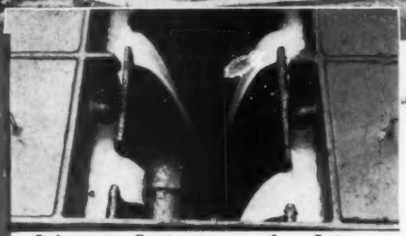
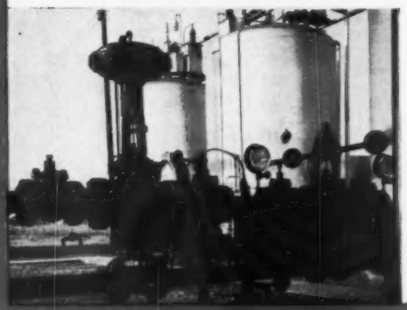


Salty water flowing to sewer from Petreco Desalters.

Salt is responsible for plugged and corroded heat exchanger tubes.



Petreco emulsifying manifold, with desalters in background.

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Petreco salt removal is accomplished by emulsifying the salty crude with fresh water, forming a *controlled* dispersion. In the Petreco treater this emulsion is subjected to the action of a high voltage electric field. The electric action "breaks" the emulsion, the purified crude oil flowing from the top of the desalter into the refinery charge stream; the salty water settling and being drawn off at the bottom of the desalter for sewage disposal. The Petreco Process is self contained, continuous and automatic.

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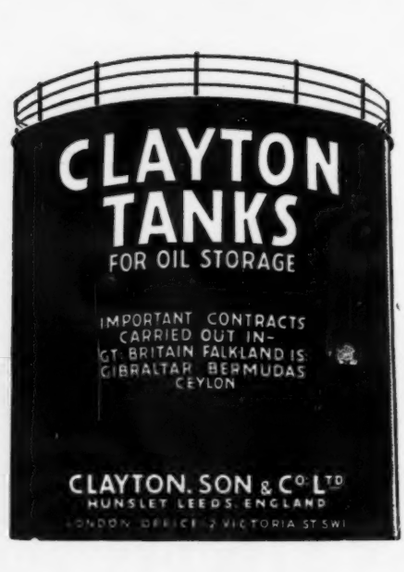

Pipe Lines and War Demands

(Continued from page 59)

1, 2 and 3 have been working for several weeks on this matter. It calls for many pipe line adjustments and reversals. The refining schedules of the Gulf Coast refineries have been affected. It calls for greater use of West Texas oils, as well as oils from the Corpus Christi area of Southwest Texas. In addition to the 8-inch line that is being built by Sinclair Pipe Line Company from Corpus Christi to Damon Mound, it is apparent that a large crude oil carrier from Corpus Christi to the Houston area is warranted. Plans are being developed for conversion of one of the large gas lines to an oil carrier from Corpus Christi to Houston to deliver approximately 75,000 barrels per day.

To augment East Coast supply of necessary winter heating oil, also as an outlet for the war plants of the Gulf Coast, it is now apparent that the War Emergency Pipe Line will operate in the first quarter of next year on something like 120,000 barrels per day of heating oil and 175,000 barrels per day of crude oil. Arrangements are being made by the War Emergency Pipe Line Company to batch these oils for transshipment at Norris City. The Coastal heating oil and some crude oils will be transmitted to Longview by reversals of one 12-inch and three 10-inch pipe lines with a total carrying capacity of approximately 165,000 barrels per day.

The natural question is: What results will be accomplished by all these pipe line projects in terms of deliveries of crude oil and products to the East Coast? Pipe line deliveries prior to the declaration of the national emergency in May, 1941, were about 42,000 barrels daily. Changes brought about thus far have increased those deliveries to nearly 135,000 barrels daily.

Upon the completion of projects now under construction, other than the War Emergency Pipe Line, it is estimated that deliveries will be increased to 208,000 barrels daily. This forecast does not include deliveries via the Southeastern Line between Port St. Jo, Florida, and Lookout, Georgia. This line is located entirely within District One. It is fed alternately by barge and tankers at the point of origin. However, it assists materially in delivering products to the southeastern states.

The forecast also does not include deliveries which will be made via the Trans-Florida line. This line will serve by barge off the eastern terminus of the Gulf Intracoastal Canal and will deliver products to Jacksonville for distribution by barge along the Atlantic Seaboard.

The use of the War Emergency Pipe Line will provide for the movement of 300,000 barrels daily into the Southern Illinois area. It is estimated that this line will result in a net increase of approximately 120,000 barrels to District One.

When the line is extended to the East Coast, it will deliver 300,000 barrels daily into the New York-Philadelphia area. Deliveries over this line to the East Coast, if increased to 450,000 barrels per day, would require the installation of 200 percent additional horsepower.

Based on an estimated essential domestic demand in District One for the period July, 1943-June, 1944, of 1,250,000 barrels daily, pipe line deliveries, not including the War Emergency Pipe Line, will amount to approximately 16½ percent of total demands. With the War Emergency Pipe Line completed to the East Coast, the percentage would be 40 percent.

The report recently filed with the War Production Board on the extension of the 24-inch line to the Atlantic Seaboard discloses that the extension would save the equivalent of 85 national tank ships (11,000DWT—10 knots). This report further shows that the pipe line extension will increase deliveries to certain overseas points with no more steel than would be required for tank ships in comparable delivery. The pipe line, moreover, would effect great savings in power equipment, manpower and money cost.

To procure the necessary pipe, pumps, motors, valves, fittings and other accessories incidental to pipe line construction has required the constant attention of the Transportation Division. Every pipe line project calls for the filing of an application with the Office of Petroleum Coordinator. These applications must be thoroughly analyzed and supported by recommendations. The applications are then processed through the Army and Navy Munitions Board and the War Production Board. Practically all of the projects referred to have been delayed because priority ratings have not been sufficiently high to procure the required materials on schedule. All lines have been designed with the minimum of critical materials. Shortage of material has meant that we have had to comb the industry for secondhand equipment, including pipe, pumps, and tankage.

New proposals, new studies, and new recommendations are being made all the time. Many new projects are now under consideration and details are being worked out to expedite completion. Outstanding among these are the numerous rearrangements necessary to provide an adequate supply of crude oil and heating oil for the 24-inch line.

I should like to point out that none of these projects could have become actualities without the closest cooperation between the oil industry and many departments of the Federal Government. The industry has painstakingly reviewed the entire pipe line transportation system with but one objective—furtherance of the war program. We have had the fullest cooperation from the Office of Defense Transportation. The Defense Plant Corporation has contributed no little in making these projects possible. It has financed the construction of a number of lines, which includes the Ohio Emergency, the Trans-Florida, the Plantation extension to Richmond, and the War Emergency Pipe Line itself.

Aside from physical construction, in pursuing our main objective to substitute fully overland transportation for tank ships, the joint program of government and industry has involved three major elements: (1) increasing the efficiency of existing transportation facilities; (2) evaluating the relative efficiency of substitute methods of transportation in terms of steel and power requirements; and (3) actually securing the critical materials necessary for expansion of facilities.

Our goal is to deliver overland approximately 1,400,000 barrels daily of petroleum to the East Coast, both for essential domestic supply and off-shore demands. Thus far we have been able to increase this overland movement from some 50,000 barrels daily in peacetime to in excess of 1,000,000 barrels per day. To accomplish our objective we have yet to gain nearly 400,000 barrels daily overland. The only answer, in our judgment, can be the building of more pipe lines.

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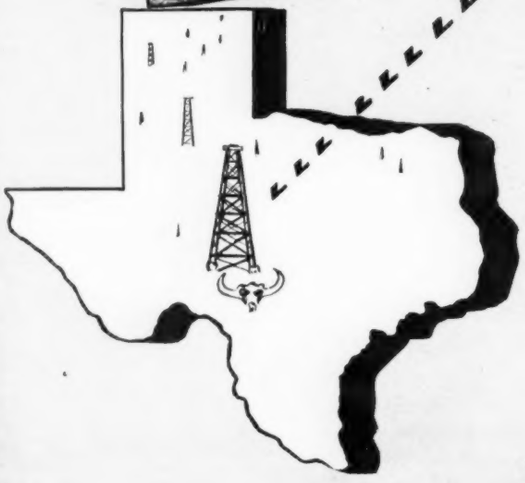
Speed, Speed and More Speed!



On the 550 mile Texas to Illinois line and other war emergency lines, Buckeye Trenchers with their "get up and go" are helping to speed these projects to completion.

Time is money, so producers and pipeline contractors alike demand speed and more speed. Almost unanimously they've found the answer in Buckeyes. Rugged, powerful "Mainliners" for trunk lines — tough, fast, compact "11's" and "12's" for gathering lines.

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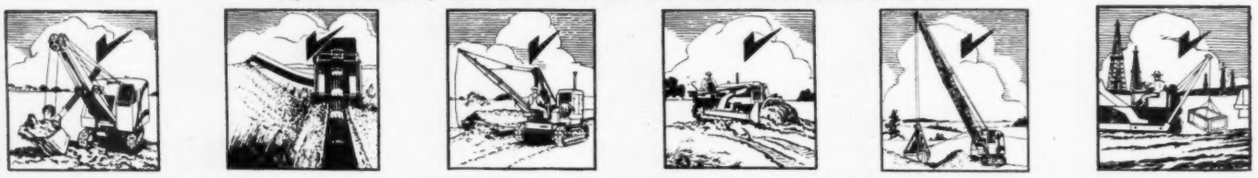

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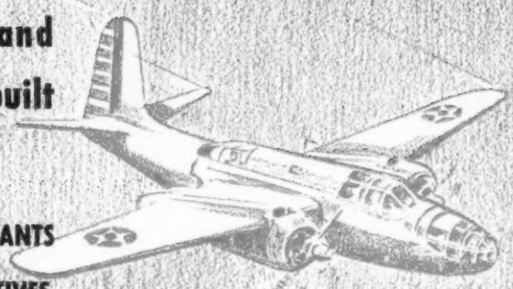

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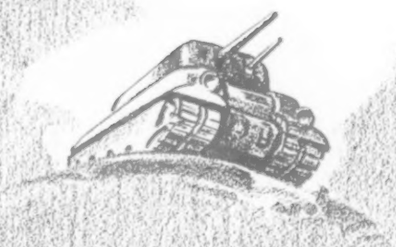

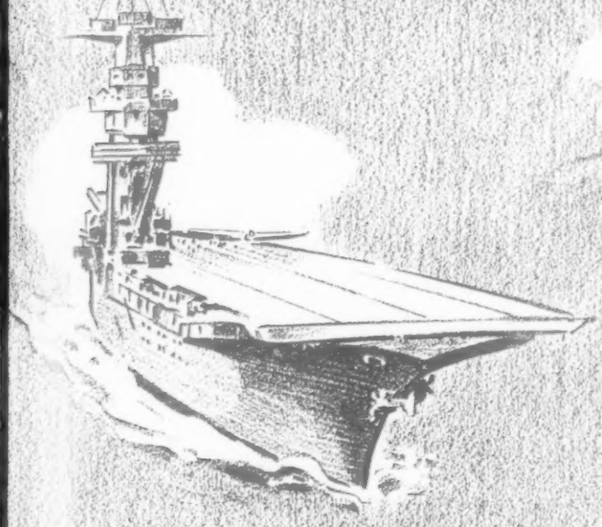

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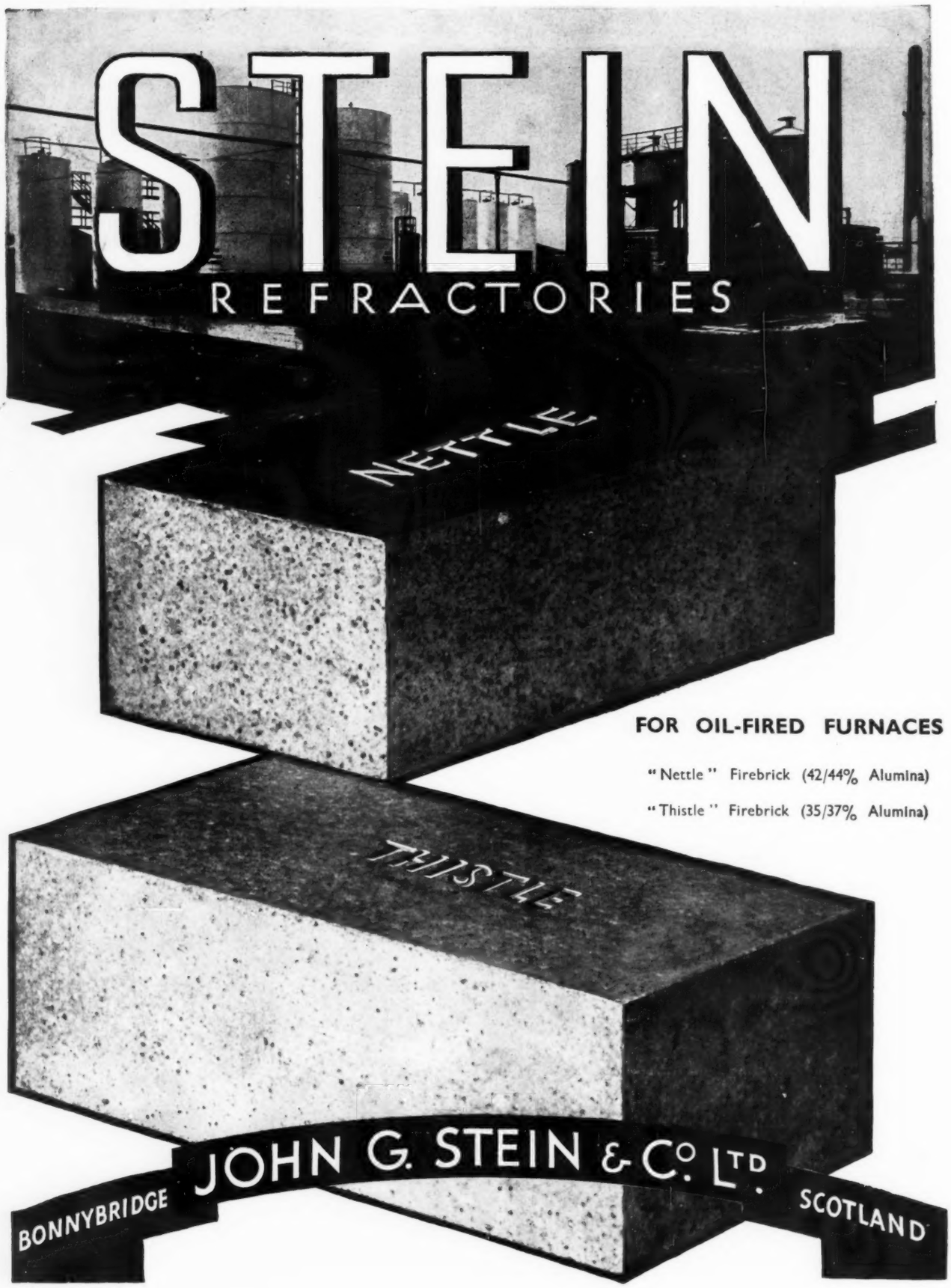
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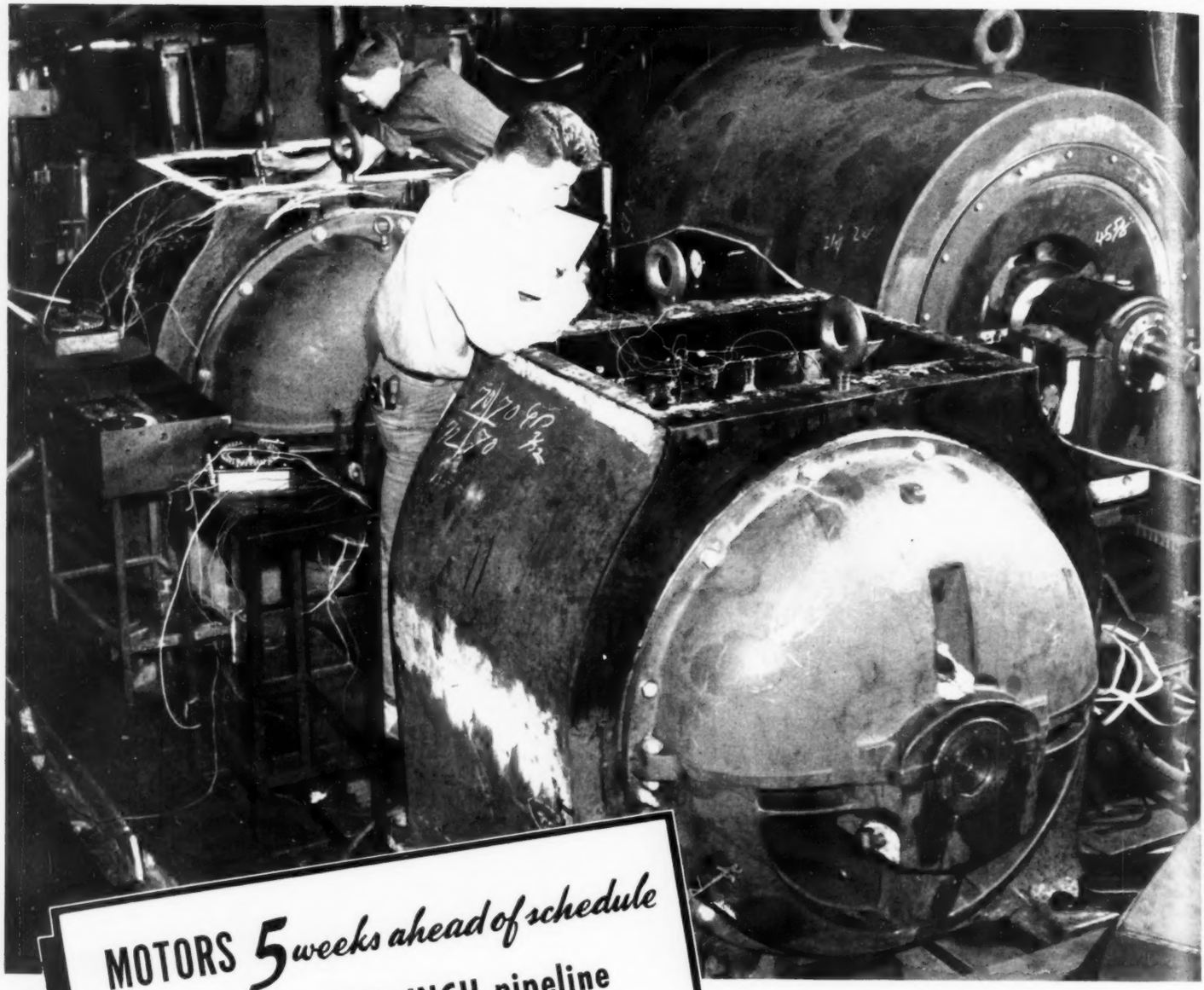

Shown during test at the factory—the first two of fifteen squirrel-cage motors (rated 1500 hp, 1800 rpm, 2300 volts) for use on the 24-inch War Emergency pipeline from Texas to Illinois.

MOTORS *5 weeks ahead of schedule*

for the BIG-INCH pipeline

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Control equipment for four pumping stations, transformers for five stations, and auxiliary pump motors for the "Big-Inch" pipeline are also under construction by General Electric.

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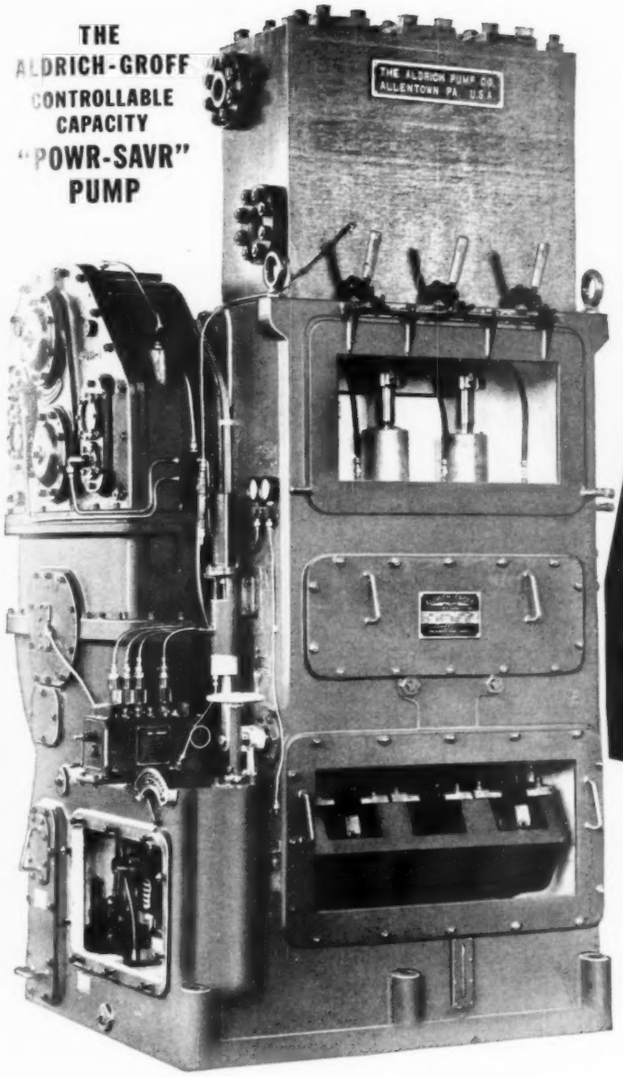

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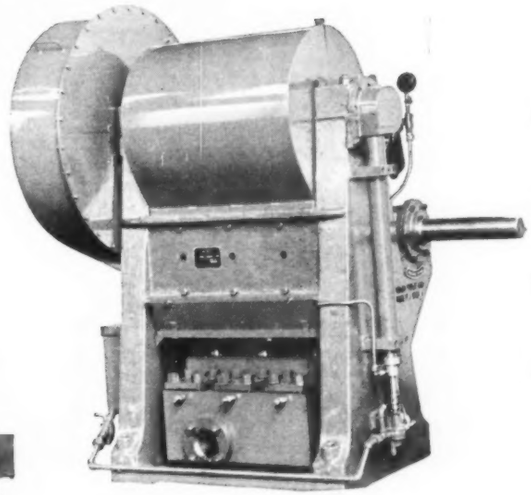

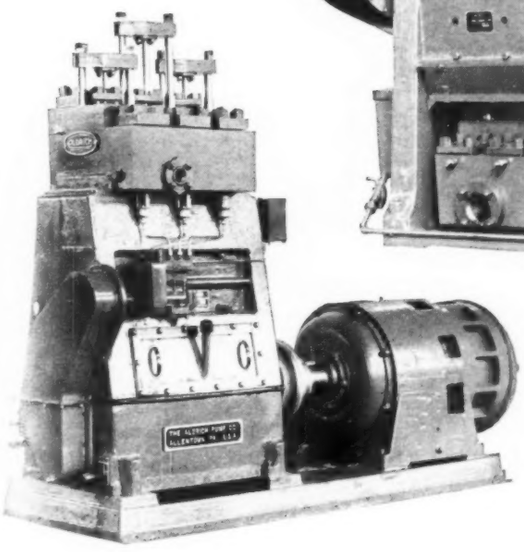

1 **THE ALDRICH-GROFF CONTROLLABLE CAPACITY "POWR-SAVR" PUMP**

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A few hours later we were awake. The thing that made us awake was treacherous and brutal, but the shock of it was as bracing as an icy shower. We knew, at last, where we stood and what we had to do.

THAT WAS A YEAR AGO...

You have a broad idea of what this nation has accomplished in its first year of war. We now report to you on what the men of one company have done and are doing.

Long before last December, "Caterpillar" Diesel Tractors and Motor Graders, Engines and Electric Sets were busy on what was then called "defense" work. With the country's entry into war, "Caterpillar" production was turned wholly to war purposes, and our plants, already working three shifts a day, stepped up their output of machines. Additional space was built. More workers were trained.

Throughout this crucial year, 100 per cent of this increased "Caterpillar" production has been going into the war effort — the vast majority of it directly to the *combat forces* of the Army, Navy and Marine Corps, and for our fighting allies. On all the world's battlefronts these machines are in the thick of the struggle for freedom. "Caterpillar" Diesel equipment is clearing beach-heads for attack troops, hauling big guns, building and repairing landing fields, drilling wells and pumping water. It is powering naval craft and generating current for lights and communications, afloat and ashore. But our report would be far from complete if it dealt only with combat activities. On the home front, thousands of older "Caterpillar" machines have been performing what appears to be a miracle. With no new machines coming from the factory to replace them — with fewer men to do the vital wartime jobs, and with heavier loads and longer hours a necessity — they have stood up under grueling punishment, month after month. In industry and construction, in mines and lumber camps and on the farms, "Caterpillar" Diesels are making a mighty contribution to the war effort.

They're no orphans—these tough, veteran machines. They are under able and expert guardianship. Back of their record of performance stand the "Caterpillar" dealers who have met the challenge of this emergency with energy and courage, and have shouldered full responsibility for keeping "Caterpillar" Diesel equipment doing its sturdy best.

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A tremendous part is being played by petroleum scientists. They have multiplied incredibly the production of 100-octane aviation gas. Most of the country's huge butadiene program for synthetic rubber is in their hands.

To both of these achievements the Houdry Catalytic Process has contributed notably. Millions of barrels of the finest aviation fuel in the world are now being produced in Houdry plants. In fact, without the principle of catalytic cracking which Houdry was the first to use commercially, America's war requirements for 100-octane gas could not have been met.

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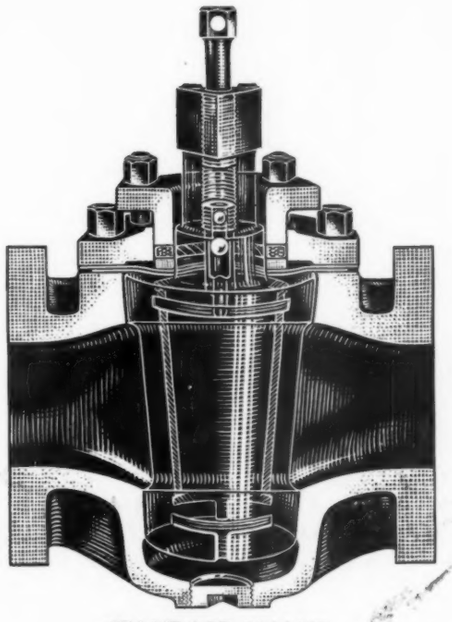

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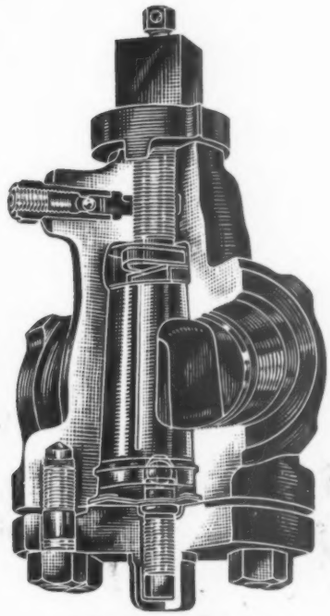

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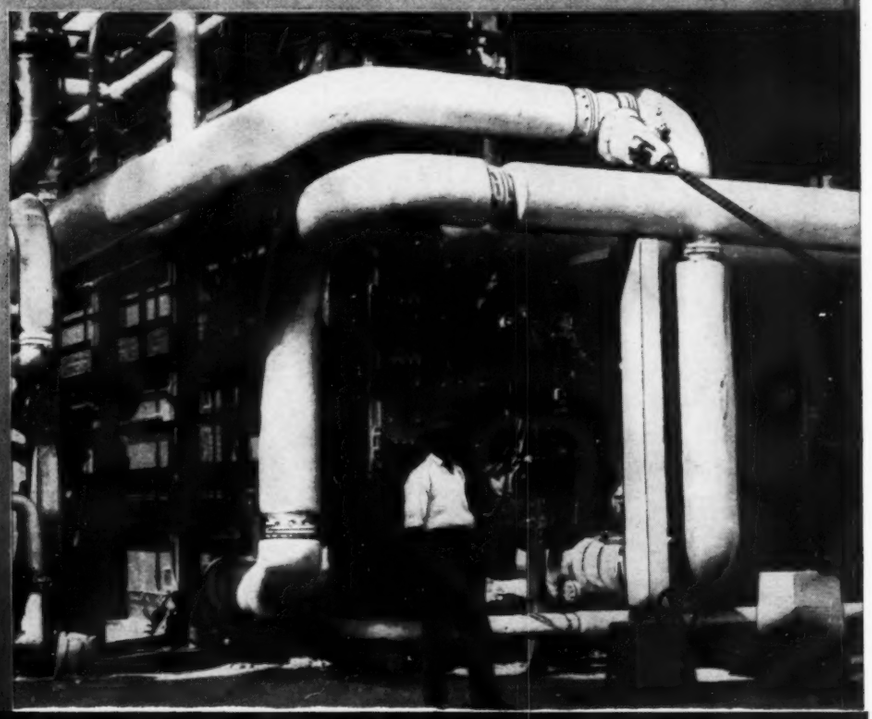

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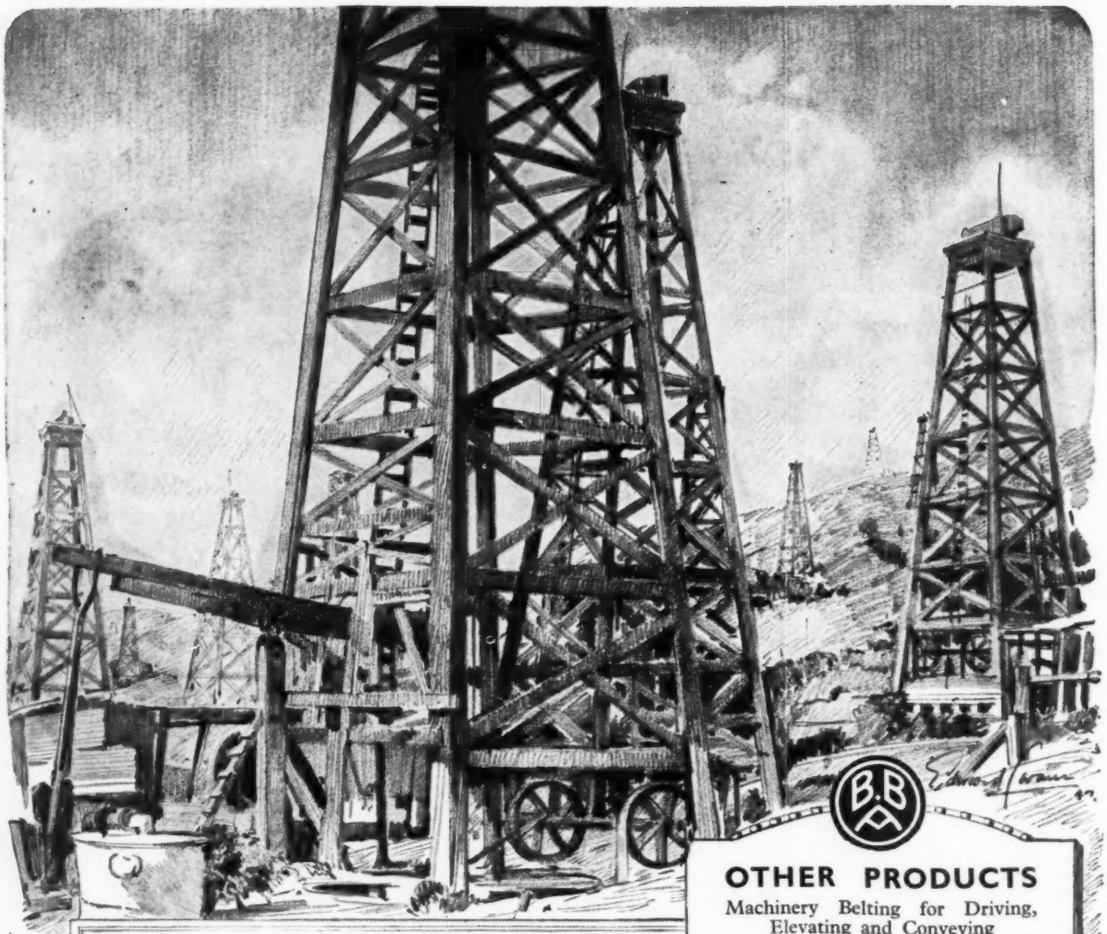

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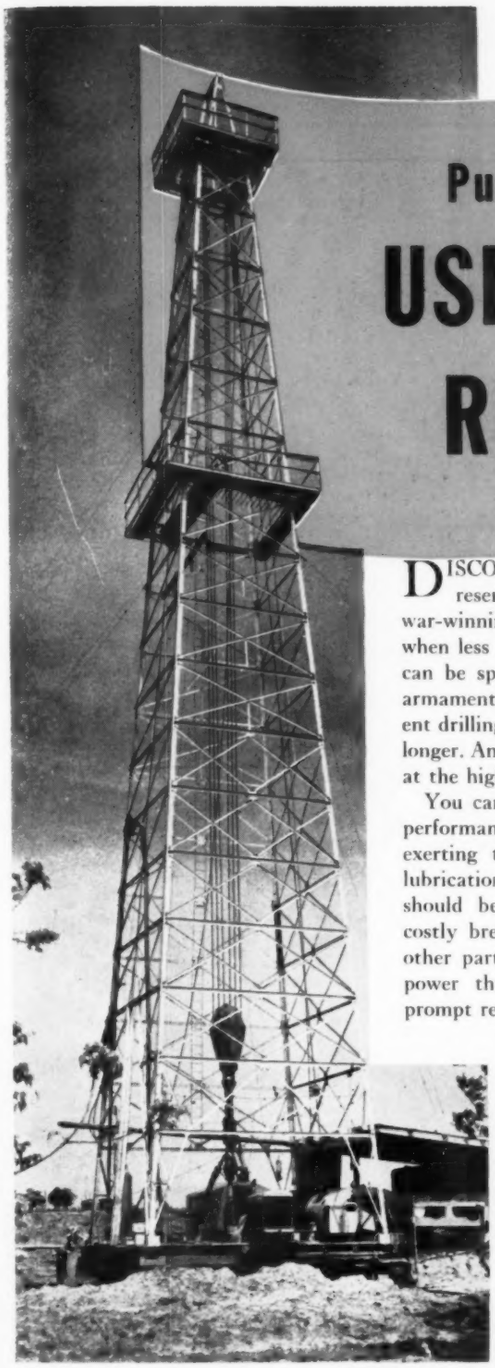

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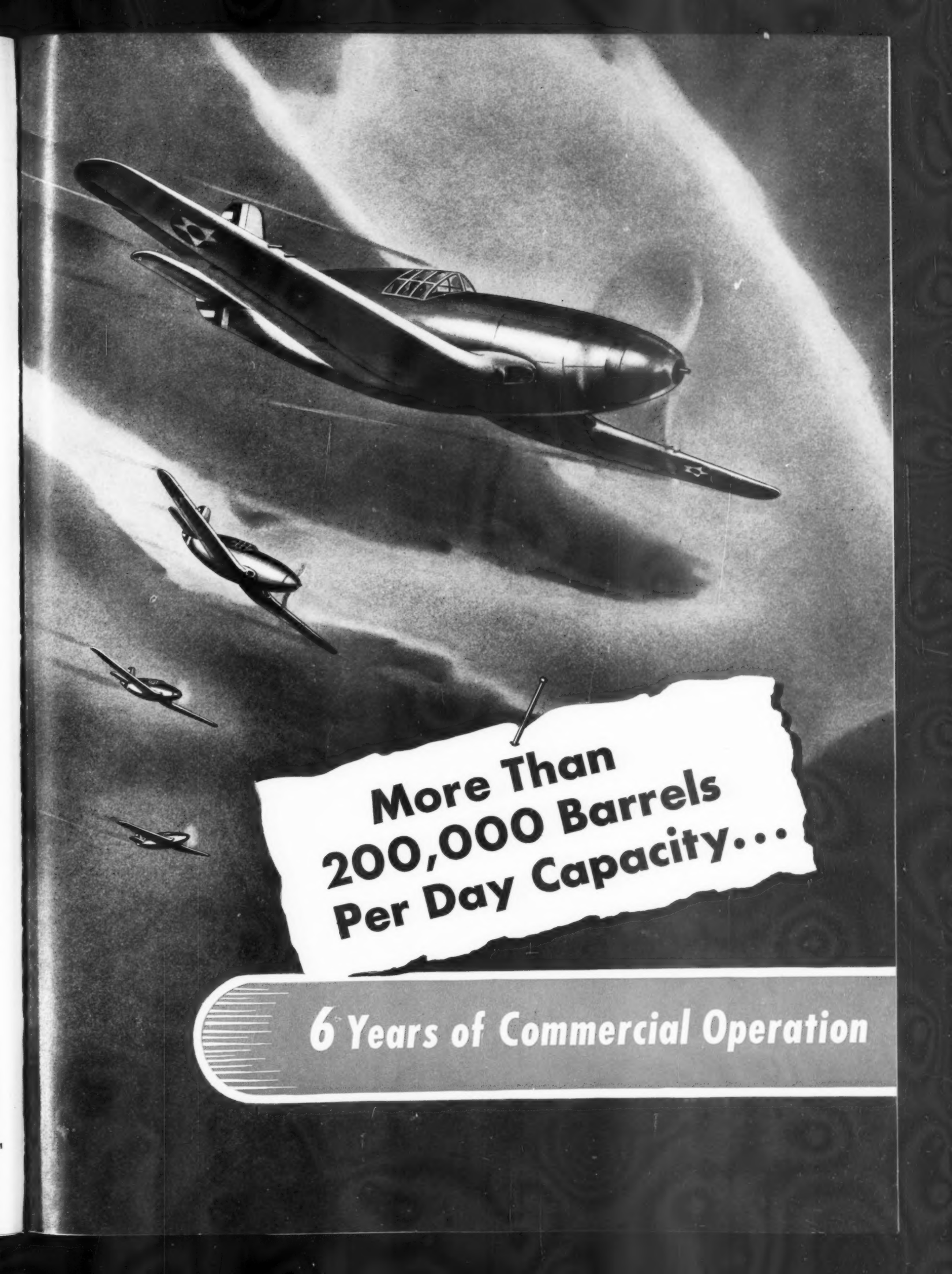
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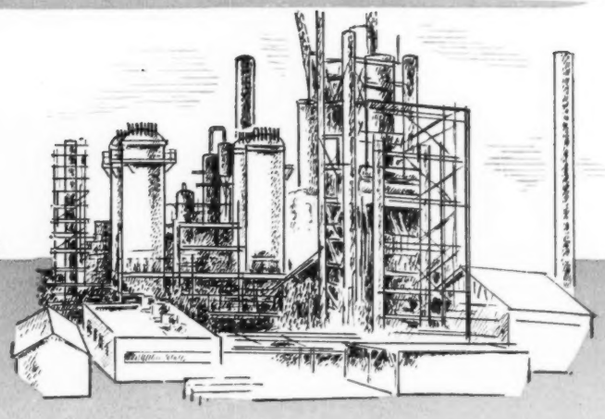

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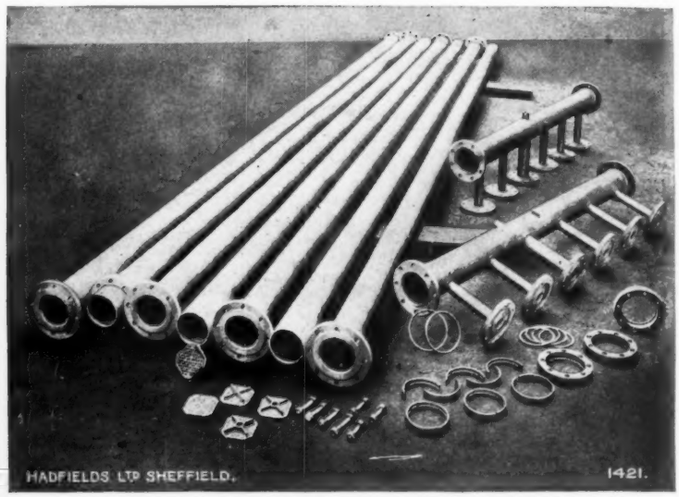

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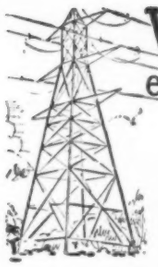

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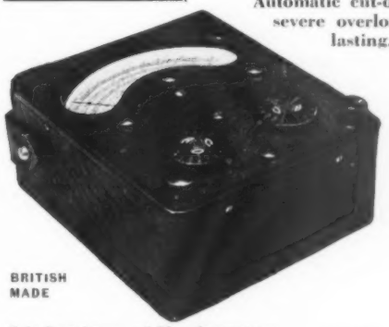

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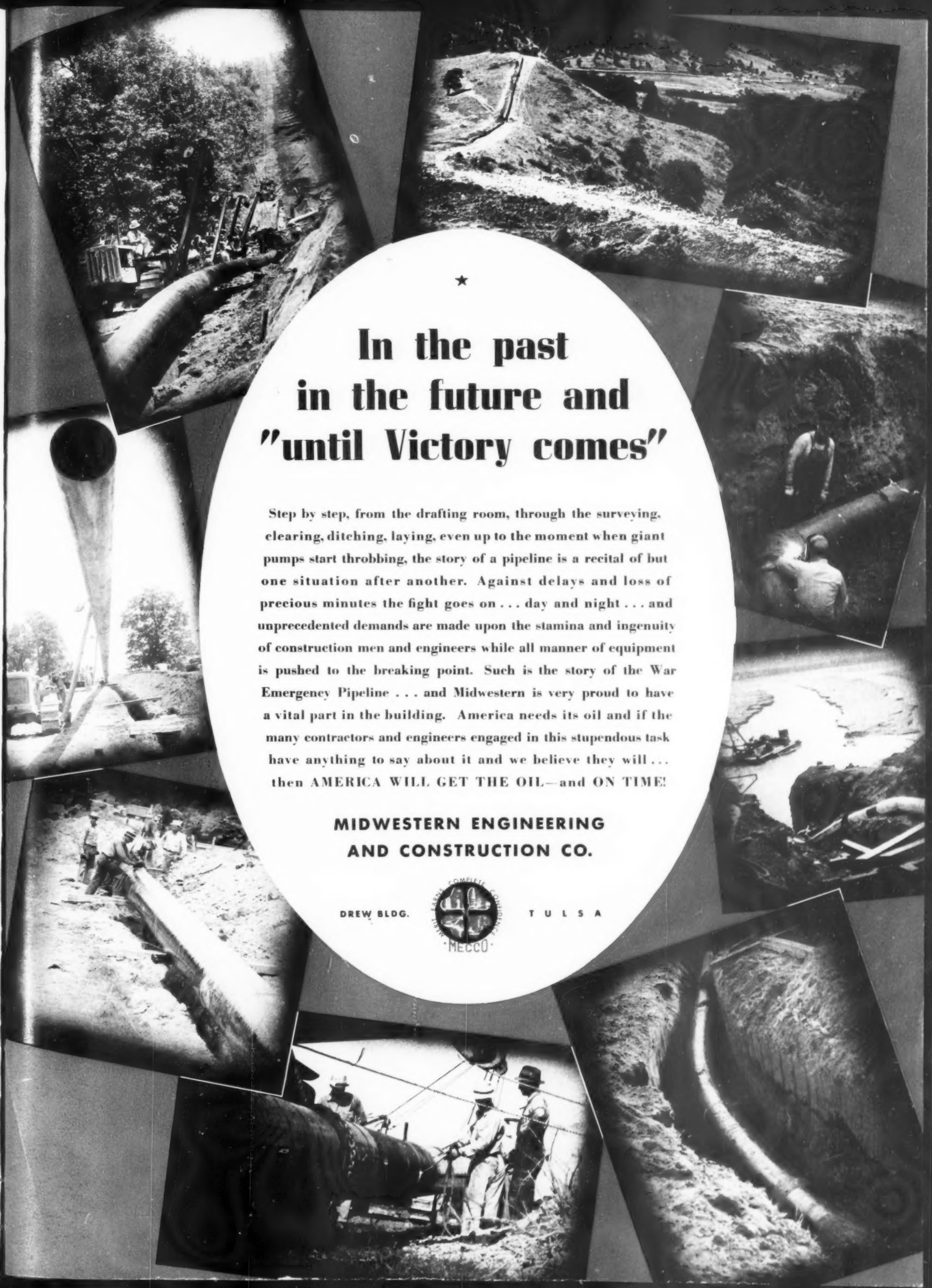

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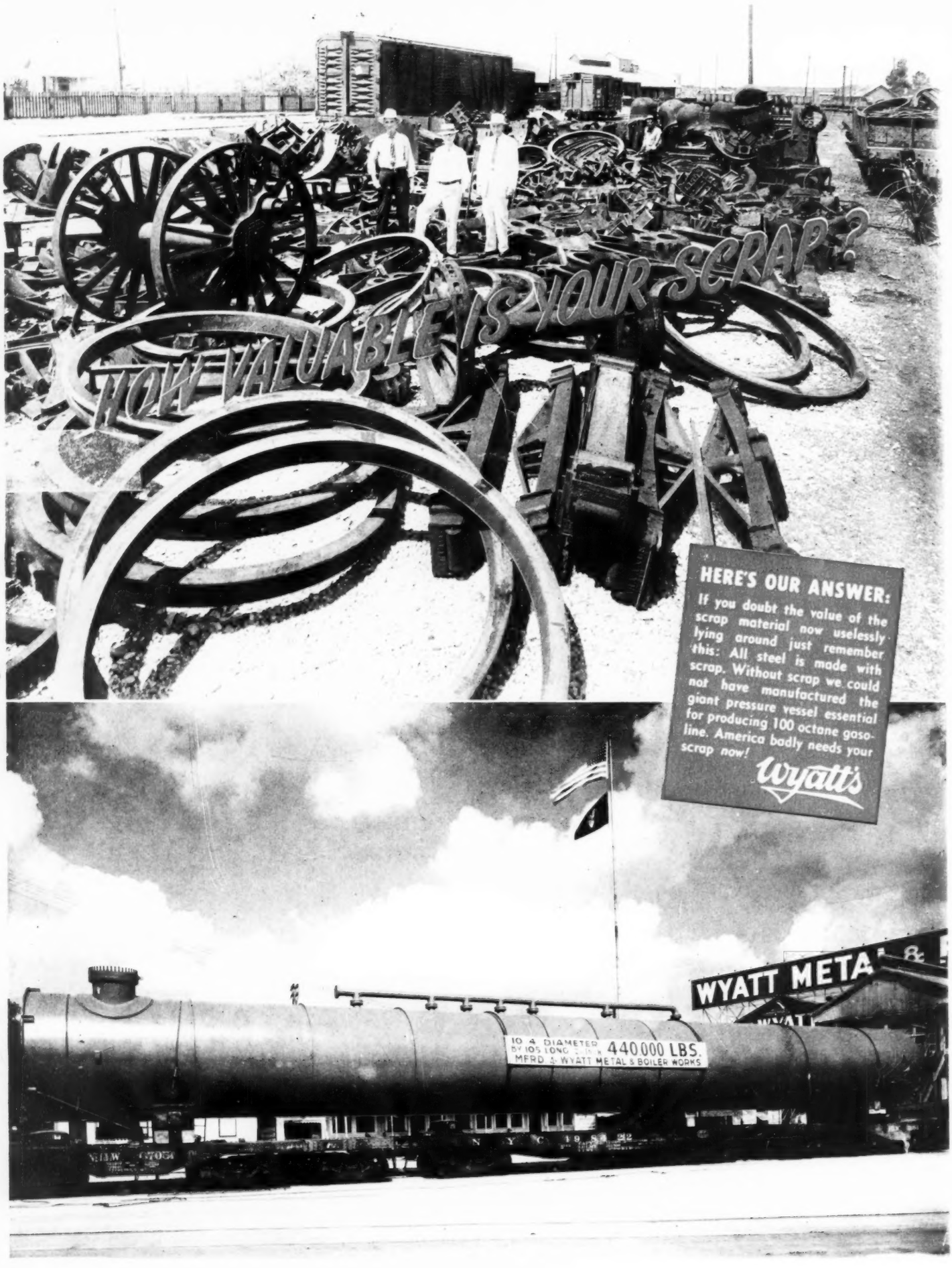
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